Motivation research in the field of sport and exercise psychology

A bibliometric study of research themes and information flow between 1985 and 2009

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Acknowledgements

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Abstract

Objectives: The objectives of this bibliometric study was to provide an overview of the intellectual structure of motivation research in the field of sport and exercise psychology (SEP), and to show how the intellectual structure of the field has changed over time. A secondary purpose was to explore the potential of longitudinal citation based science mapping within SEP, and further, in the sub-area of motivation research in SEP.

Research questions: (1) How did the intellectual structure of motivation research within the field of SEP evolve between 1985 and 2009 with respect to research themes and topics? (2) How did the flow of information, in terms of citations, between sub areas take shape within motivation research in SEP between 1985 and 2009?

Data: 739 articles published between 1985 and 2009 were used in this study. Field delineation and data collection was conducted with a multi-database approach based on controlled vocabulary. The dataset was furthermore expanded by citation-based extension.

Methods: A cluster analysis was performed on the retrieved articles based on normalized bibliographic coupling (i.e., based on shared references topically similar articles was placed in mutually exclusive groups). The cluster analysis resulted in 19 clusters that were classified by a subject expert from the field of SEP. Further, the labeled clusters were visualized as research fronts along timelines subdivided into timeslices – 1985-1994; 1995-1999; 2000-2004; 2005-2009 – showing the growth and decline of research topics within motivation research in SEP. Direct citations between the research fronts was extracted and visualized in order to explore information flow.

Results: Some main findings were: (1) timeslice 1985-1994 consisted of a dispersed collection of research fronts. No dominating research theme or theoretical framework could be discerned in this period; (2) the timeslices of 1995-1999 and 2000-2004 was dominated by achievement goals oriented research; (3) during timeslice 2004-2009 self-determination theory oriented research underwent a drastic growth. This timeslice was dominated by achievement goals oriented research and self-determination theory oriented research. In the direct citation network highly influential research fronts (i.e., influential research themes) could be identified. The top five with respect to received direct citations was: (1) Task-ego achievement goals 1; (2) Task-ego achievement goals 2; (3) Self-determination theory 1; (4) Motivational climate; (5) Percieved competence and motivation among children and youth.
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1. Introduction
In this quantitative research review, bibliometric methods was used to map the intellectual structure of motivation research conducted in the field of sport and exercise psychology (SEP) between 1985 and 2009. The time frame of this study – 1985-2009 – was dynamically subdivided into one ten-year period, 1985-94, and three five-year periods, 1995-1999, 2000-2004, 2005-2009, in order to address the longitudinal perspective.

In two earlier studies, Lindahl (2011) and Lindahl, Stenling, Lindwall, and Colliander (2012), where different aspects of the intellectual structure of SEP was examined between 2008 and 2011, the results showed that motivation research was the largest sub-area within the field.

1.1 Objectives and research questions
The objective of this study was to provide an overview of the intellectual structure (i.e., research themes and topics) of motivation research in SEP, and to show how the intellectual structure of the sub-field has changed over time. To be more specific, with the longitudinal perspective two aspects of motivation research within SEP was investigated: (1) the growth and decline of identified sub areas, and (2) the flow of information between these sub areas (i.e., influential sub areas in terms of the contribution of useful knowledge, and in which sub areas this knowledge is used). For these purposes the following research questions was articulated:

- How did the intellectual structure of motivation research within the field of SEP evolve between 1985 and 2009 with respect to research themes and topics?
- How did the flow of information, in terms of citations, between sub areas take shape within motivation research in SEP between 1985 and 2009?

Due to the lack of similar studies regarding methodology and object of analysis, the longitudinal aspect of motivation research in SEP was in this study viewed as a secondary purpose, involving the examination of possibilities and limitations of longitudinal citation based science mapping studies in the specific sub-area of motivation research in the field of SEP, and furthermore, within the field of SEP as a whole.

2. Motivation research in sport and exercise psychology
The object of analysis in this study was motivation research within the field of SEP. This section consists of two parts. In the first part a brief review of earlier research reviews
concerning motivation research in SEP is conducted. In the second part definitions of the field of SEP and motivation research within SEP is presented.

2.1 A brief review of the literature
During the 1970s and 1980s sport and exercise psychology research develops into an academic sub-discipline within psychology in its own right with the start of a number of core journals (see Table 2, page 21). The systematic study of motivation in a sport and exercise psychology context has been pursued since 1970s (Roberts, 1992, p. v). According to Mayer, Faber, and Xu (2007), who reviews the literature on motivation measures between 1930 and 2005, motivation measures in the context of SEP starts developing during the 1980s.

Even though no former research reviews similar to this study – with respect to aim and methodology – could be found, some research reviews, and review sections within empirical articles and textbooks, relevant for the scope and timeframe of this study could be identified. Most of the former reviews and relevant literature consist of (1) review articles with a broad scope, covering the field of SEP or motivation research within SEP (e.g., Biddle, 1997; Biddle, 1999; Chatzisarantis, Hagger, Biddle, Smith, & Wang, 2003); (2) reviews of specific sub topics within the context of motivation in SEP (e.g., Martin, Moritz, & Hall, 1999; Ntoumanis & Biddle, 1999; Vallerand & Losier, 1999); and (3) textbooks reviewing the development of research themes associated with, or within the context, of motivation research in SEP (e.g., Hagger & Chatzisarantis, 2007; Roberts, 1992; Roberts & Treasure, 2012). The majority of these reviews consist of qualitative content analysis.

Some outlines could be identified by studying the review literature concerning the development of motivation research in SEP. There seem to be an agreement in the literature that from the 1970s the cognitive paradigm has been important to the study of motivation within the field of SEP. In the context of SEP the cognitive paradigm consists of number of theories where it is assumed that “behavioral variance in sport and exercise is [...] captured by models that incorporate the cognitions and beliefs of individuals; in other words, the cognitions and beliefs of individuals mediate their behavior” (Roberts, 1992, p. 8). Roberts (1992, p. 8-15) outlined the theoretical frameworks of attribution theory; theory of self-efficacy; motivation theories revolving around perceived competence; and achievement goals approaches, as the dominating theories and approaches at the time. According to Biddle (1999), achievement goals orientations was “the ‘hot topic’ of sport psychology in the late 1990s, [and] attribution theory was certainly the equivalent in the 1980s” (Biddle, 1999, p. 7). Furthermore, Biddle predicts self-determination theory as the leading framework in the future
In Roberts and Treasure (2012), the dominating contemporary theories are identified as organismic (e.g., self-determination theory; hierarchical goal model) and social-cognitive theories (e.g., achievement goal theory; theory of self-efficacy).

2.2 Definitions

In order to find a definition of the field of sport and exercise psychology, I consulted a subject expert from the field of SEP.\(^1\) With respect to the methods used in this study, I wanted a broad definition of the field and was recommended to use the definition proposed by the European federation of sport psychology (FEPSAC, 1995):

Sport psychology is concerned with the psychological foundations, processes and consequences of the psychological regulation of sport-related activities of one or several persons acting as the subject(s) of the activity. The focus may be on behaviour or on different psychological dimensions of human behaviour, i.e. affective, cognitive, motivational or sensori-motor dimensions. The physical activity can take place in competitive, educational, recreational, preventative and rehabilitation settings and includes health-related exercise. Subjects are all persons involved in the different sport and exercise settings, e.g. athletes, coaches, officials, teachers, physiotherapists, parents, spectators etc. (p. 1)

The field of SEP is characterized by a high degree of interdisciplinary and applied research. Three main areas can be discerned: (1) sport practice, (2) psychology, and (3) other sport sciences. The relationships between these areas are described in FEPSAC (1995) as follows:

1. Sport psychology – Sport practice: Sport psychology is faced with issues that arise from exercise and sport practice. It tries to better understand these demands and attempts to give assistance in satisfying them.

2. Sport psychology – Psychology: Sport psychology is an applied subdiscipline of psychology. It partly draws upon knowledge adopted from different branches of psychology and contributes to the further understanding of psychology in general.

3. Sport psychology – Other sport sciences: Sport psychology is one discipline of the sport sciences. The more sport psychology generates specific knowledge by empirical work in the field of sport and physical activity, the more the findings and methods of

\(^1\) The subject expert is a member of the Sport psychology group at the Institution of psychology at Umeå University.
other sport sciences have to be accounted for. Some questions may be answered using interdisciplinary approaches. (p. 1)

Many suggestions have been made concerning a definition of the concept of motivation within the discipline of psychology, as well as within the field of SEP (Kleinginna & Kleinginna, 1981). I was looking for a broad definition of motivation research in SEP and by consulting a subject expert the following definition was formulated:2 Motivation research within SEP refers to a set of problems, topics and themes, theories and methods related to and used in a SEP context, where motivation can be defined as “the investigation of the energization and direction of behavior” (Roberts, 1992, p. 6).

Due to the broad scope of this definition a second criteria was imposed during the data collection phase: for an article to be validated as motivation research in SEP, motivation had to be a variable in the conducted study.

3. Theoretical framework
This section consists of five headings. The first four consist of (1) an introduction to bibliometrics in terms of definitions and terminology; (2) formal scientific communication and bibliometrics; (3) citation analysis and citation databases; (4) and citation theory. Under heading five the concepts of research specialty and timeline visualization are presented.

3.1 Bibliometrics and science mapping: definitions, contexts and terminology
Bibliometrics refers to the “quantitative analysis of bibliographic data” (Noyons, 1999, p. 3) and is applied within at least four areas (Noyons, 1999, p. 4-5): (1) Performance analysis, where the performance of scientific research units is evaluated with respect to activity, productivity and impact; (2) Information retrieval, where bibliometric methods is used in the process of information seeking; (3) Library management, where bibliometrics is used in the context of libraries (e.g., to manage journal collections); and (4) Science mapping, which is concerned with the analysis and visualization of the structure and development of science: the application area to which this study belongs.

The variables used in bibliometric analyses is extracted from bibliographic data – metadata assigned to describe and identify publications (Kärki, Kortelainen, Eriksson, & Ungern-

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2 For a contextualization of this definition with respect to the hierarchy of science and a model for formal scientific communication, see section 3.5 Timeline visualization of research specialties.
Sternberg, 1998, p. 6). Publications, (co-)authors, references and citations are the most common variables used in bibliometric analyses (Glänzel, 2003, p. 12).

In bibliometrics references and citations denote two different concepts, their relationship can be expressed as follows (Egghe & Rousseau, 1990):

If paper R contains a bibliographic note using and describing paper, C, then R contains a reference to C and C has a citation from R. Stated otherwise, a reference is the acknowledgement that one document gives to another, while a citation is the acknowledgement that one document receives from another. (p. 204)

Thus, references are given by documents and citations are received by documents. As suggested above a distinction need to be made between bibliometric analyses that are based on the concept of references and bibliometric analyses based on citations. In reference based analyses, the cited references in the reference list of a document are analyzed from the point of view of the citing document, and in citation based analyses, the received citations are analyzed from the perspective of the cited document (Kärki et al., 1998, p. 10).

In bibliometric analyses a variable is examined in order to gain knowledge of a bibliometric unit, which consists of a population of documents (e.g., books; reports; patents; articles) collected with respect to some criteria (e.g., a specific subject area; a number of journals; an author; an institution; a continent) (Glänzel, 2003, p. 12). To exemplify, by counting the number publications of a bibliometric unit (e.g., a researcher) during a given period of time, a measure of productivity, or outcome, is obtained. A measure of influence or impact, on the other hand, is obtained if the variable is changed to citations (i.e., received citations). These types of measures are called bibliometric indicators.

Gauthier (1998, p. 10) subdivides the numerous bibliometric indicators into two main categories:

1. Descriptive indicators
2. Relational indicators

Descriptive indicators are generally used within the application area of performance analysis, where focus lies on research activity, productivity and impact, while relational indicators measures relationships – in terms of similarity, or association – between bibliometric units on different levels of aggregation (e.g., documents; authors; universities; countries). Relational indicators are used within the application area of science mapping in order to, first and
foremost, map the structure of social networks and knowledge domains in science (Morris & Martens, 2008, p. 215). Relational indicators usually measures, either the relationship between bibliometric units, or between tokens (e.g., cited references; words; authors) co-occurring within bibliometric units. In science mapping a number of relational indicators are used. Here I briefly describe three very common citation-based measures in science mapping, of which two – bibliographic coupling and direct citation – were used in this study:

1. **Direct citation** (DC), measures topical similarity by identifying citation links between documents. A DC occurs when one document cites another document (Boyack & Klavans, 2010, p. 2391). DC is not widely used in science mapping, but has the nice quality of showing the actual flow of information within knowledge domains (Persson & Ellegard, 2012, p. 251).

2. **Bibliographic coupling** (BC)

3. **Co-citation**, was introduced by Small (1973), and measures association, or similarity as perceived by citers, between cited documents. A co-citation occurs when two documents are cited by a third document. Thus, while BC measures similarities between citing documents, co-citations measures similarities between cited documents.

The specific citation based relations between documents concerning the three measures of DC, BC, and co-citation are depicted in Figure 1.

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Due to the importance of BC to this study a more detailed presentation (e.g., computational aspects, normalization etc.) of the concept is provided in section 4.1.2 Bibliographic coupling.
Figure 1. Show citation relations where B cites A = DC; A and B cites C = BC; and A and B are both cited by D = co-citation (modified from Persson (2010)).

3.2 Formal scientific communication

A basic assumption in bibliometrics is that the published literature mirrors the research activities. Therefore, by the analysis of the published literature (i.e., the *formal scientific communication* (FSC)), a view of science can be obtained (Kärki et al., 1998, p 1). Further, a prerequisite for this assumption, as pointed out by Lundberg (2006, p. 10), is that most of the relevant research is published and made available to the scientific community. FSC can be defined as communication between science producing units occurring through the official channels of the scientific community (e.g., peer reviewed articles, monographs, chapters in books). The most influential model of FSC – according to Cronin (1984, p. 11) – is the scientific journal in which peer reviewed articles are published. The scientific journal fulfills at least 4 important functions within the scientific community (Cronin, 1984, p. 11):

1. It’s a medium that enables the communication between researchers.
2. The system of peer review guaranties the quality of the publications.
3. The journal works as a channel for the researcher to demonstrate the originality and value of his/hers research.
4. It provides a medium and a system by which acknowledgements can be distributed between researchers in terms of citations.

However, even though the scientific journal and the peer review article is the main channel for FSC in many scientific disciplines, the channels for FSC and publication praxis tend to differ between different disciplines and fields. To exemplify, within the humanities monographs are suggested as the most important publication channel (Hammarfelt, 2012, p.
28-30), and in some technical fields, conference proceedings are very important in terms of their FSC (Butler, 2008; Glänzel, Schlemmer, Schubert, & Thijs, 2006). Due to the different publication practices within science, and limitations – in terms of coverage of certain publication formats (e.g., books) – in the databases used to collect the data for bibliometric analyses, a first step in bibliometric science mapping is to determine the appropriateness of using bibliometric methods to examine the FSC of a certain discipline or field (Kärki et al., 1998, p. 41).

3.3 Citation analysis, citation databases and motivation research in sport and exercise psychology: possibilities and limitations

A central principle and practice in science is that new research builds upon older research, and that the newer research denotes its sources by referencing them. In bibliometrics it is assumed that indications of the structure and developments of science, as well as indications of quality, influence and impact, can be obtained by analyzing the distribution of citations between scientific publications on different levels of aggregation. Such studies falls under the umbrella term, citation analysis (Kärki et al., 1998, p. 11). In the context of science mapping, citation analysis is used to investigate relationships between bibliometric units (e.g., publications, authors, journals) on the basis of citations and references (e.g., by applying co-citation analysis or BC). The data is usually collected from “bibliographical citation databases where research articles are indexed and made accessible as bibliographic records” (Jarneving, 2005, p. 21), and in addition to the usual meta data, these bibliographic records also contain the reference list of the indexed document so that citation links between documents can be identified and extracted.

In order to determine the appropriateness of the application of analyses within the framework of citation based science mapping in a particular field, two questions arises: (1) how are the publication practices within the field under study? And (2) are there any bibliographic citation databases that appropriately cover the FSC of the field?

In this study I used an article set collected from the citation indices of Thomson scientific through Web of science (WoS). WoS was chosen (1) due to the longitudinal perspective of this study, it was the only identified bibliographic citation database with bibliographic records containing cited references as far back as needed, and (2) due to the interdisciplinary character of the citation indices of WoS, which was a requirement in this study due to the interdisciplinary character of motivation research in SEP. WoS covers the FSC of the hard sciences very well (e.g., physics; chemistry; molecular biology), where the FSC model of the
scientific journal with the peer reviewed article is the dominating one, but does not cover the FSC of the humanities and social sciences (to which psychology belongs) to the same extent. Thus, bibliometric analyses based on data from WoS works best within research fields from, or similar to, the hard sciences in terms of publication practices. However, publication practices differ between disciplines and areas within the social sciences. In Hicks (2004, p. 2) it is shown that the FSC of the discipline of psychology are quite similar to the FSC of the hard sciences, and further concluded that bibliometric studies based on WoS in the discipline of psychology works reasonable well. A similar conclusion is found in Moed (2005) where the coverage of a number of fields in WoS are analyzed: “Psychology […] are more similar to science fields, and show good, yet not excellent [WoS] coverage” (Moed, 2005, p. 148). A further indication of the appropriateness of performing bibliometric analyses within the discipline of psychology are the numerous bibliometric studies – based on WoS data, as well as other databases – that have been conducted on different levels within the framework of the discipline (e.g., Garcia-Martínez, Guerrero-Bote, & de Moya-Anegon, 2012; Navarrete-Cortes, Fernandez-Lopez, Lopez-Baena, Quevedo-Blasco, & Buela-Casal, 2010). Nevertheless, due to the fact that publication practices differ within disciplines, definite conclusions of the publication practices in SEP can not necessarily be drawn from studies of the publication practice of psychology on the discipline level. SEP is a relatively unexplored sub-field in psychology in terms of bibliometric science mapping. Although citation based analyses have been conducted within other sub-areas within SEP (e.g., Bruner, Erickson, Wilson, & Cote, 2010; Bruner, Erickson, McFadden, & Côté, 2009), no bibliometric studies of the sub-area of motivation research within SEP could be identified.

In Lindahl (2011), and Lindahl et al. (2012) citation based analyses based on WoS data was used to map the intellectual structure of the field of SEP between 2008 and 2011. The results were validated by subject experts that could confirm that the analyses and maps provided a representative overview of the field. The results from these two studies indicated that the field of SEP can be appropriately covered by WoS data, as well as the sub-area of motivation research, at least between 2008 and 2011. The possibilities and limitations concerning a longitudinal study of motivation research in SEP based on WoS data could not be predetermined, and has been viewed as a secondary exploratory purpose of this study: To examine the possibilities and limitations of longitudinal citation based science mapping studies within the field of SEP, and further, in the specific case of motivation research in SEP.

Another limitation of this study is that it first and foremost, is based on English-language articles. Thus, this study covers the internationally oriented motivation research in SEP.
3.4 Citation theory

According to Moed (2005, p. 209) it is important that bibliometric indicators has a sound theoretical foundation and are empirically tested and validated. In this section citation theory is briefly presented, along with the theoretical underpinnings of this study regarding the interpretation of BC and DC.

Citation theory tries to answer questions concerning the interpretation of references and citations in bibliometric analyses: what do citation-based indicators measure, and how can they – to exemplify – be related to concepts such as intellectual/cognitive influence, or topical similarity between documents?

Within the framework of citation theory a number of theoretical positions can be found spanning over a wide variety of disciplines (e.g., physics, sociology, psychology, history). Moed (2005) subdivides the numerous theoretical positions into two main categories: (1) a social constructive point of view, and (2) a citation-analytical point of view. According to Moed (2005):

A social constructive view of referencing behavior analyses the social conditions and interactions involved in the publication process. It does not negate that a cited paper has a reality of its own, or an identity that also exists outside the world of the citing author, but its primary interest lies in analyzing how it may be influenced by the social environment in which it is produced. (p. 213)

And:

A citation-analytical perspective assumes that – under certain conditions – citation analysis may provide valid indications of the significance of a document. Such indications may be denoted as objective in the sense that they reflect properties of the cited document itself, and that they are replicable, and based on the practices and perceptions of large numbers of (citing) scientists rather than on those of a single individual scientist. (p. 213)

The citation-analytical perspective is the dominating perspective within bibliometrics, and is usually – to a larger or smaller extent – founded in the sociologist Merton’s theory of science as a normative and reward based system, where citations are interpreted as acknowledgements given in order to pay intellectual debts and to give recognition to peers for significant contributions to the development of science. With Merton’s “normative” view, the degree of
received citations of a bibliometric unit can be interpreted as an indication of intellectual influence of that unit within an area of research (Moed, 2005, p. 200-201). The social constructive view corresponds to (1) the so called rhetorical system⁴ of science and can be understood as a critique of the citation-analytical view. An extreme position within the rhetorical system is found in Latour’s theory of citations where it is assumed that researchers primarily give references for rhetorical purposes (i.e., in defense of attacks, to promote an argument, convince others and to advance the career of the researcher) (Lundberg, 2006, p. 11). The social constructive view also corresponds to (2) the so called communication system⁵ of science, which refers to limitations imposed on the referencing behavior, as well as the potential of receiving citations, based on factors such as communication and information flow (e.g., language, access, size of audience, degree of specialization, etc) (Kärki et al., 1998, p. 42; Moed, 2005, p. 215).

While the social constructive perspective tend to focus upon particularities in reference behavior, the citation-analytic perspective tend to focus upon the identification of patterns in large quantities of citation based data. A common critique of the citation-analytical perspective is derived from the examination of the motives behind the practice of giving references. Such examinations usually show that the act of giving references depends on a wide variety of motives (see Table 1), that are not necessarily in line with the “mertonian” view of science and referencing practices. A social constructive interpretation of this phenomenon could be that high citation counts basically reflect a multiplicity of personal motives, shaped by different experiences, circumstances and social contexts, and are therefore not suitable as measures of concepts such as impact, importance, influence or utility (Moed, 2005, p. 213).

⁵ See Cozzens (1989).
Table 1. 15 reasons for giving citations (Garfield, 1965) and 26 relations between cited and citing documents (Duncan, 1981) (modified from Lundberg, 2006).

<table>
<thead>
<tr>
<th>Garfield</th>
<th>Duncan et al.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Paying homage to pioneers</td>
<td>1. Paying homage</td>
</tr>
<tr>
<td>2. Giving credit for related work (homage to peers)</td>
<td>2. Background reading</td>
</tr>
<tr>
<td>3. Identifying methodology, equipment etc.</td>
<td>3. Historical</td>
</tr>
<tr>
<td>4. Providing background reading</td>
<td>4. Bibliographical leads</td>
</tr>
<tr>
<td>5. Correcting one's own work</td>
<td>5. Narrative</td>
</tr>
<tr>
<td>6. Correcting the work of others</td>
<td>6. Definition</td>
</tr>
<tr>
<td>7. Criticising previous work</td>
<td>7. Clarification</td>
</tr>
<tr>
<td>8. Substantiating claims</td>
<td>8. Illustration</td>
</tr>
<tr>
<td>10. Providing leads to poorly disseminated, poorly indexed, or uncited work</td>
<td>10. Experimental detail</td>
</tr>
<tr>
<td>11. Authenticating data and classes of fact - physical constants, etc</td>
<td>11. Theory</td>
</tr>
<tr>
<td>12. Identifying original publications in which an idea or concept was discussed</td>
<td>12. Data</td>
</tr>
<tr>
<td>13. Identifying original publications or other work describing an eponymic concept or term</td>
<td>13. Methodology</td>
</tr>
<tr>
<td>14. Disclaiming work or ideas of others (negative claims)</td>
<td>14. Description</td>
</tr>
<tr>
<td>15. Disputing priority claims of others (negative homage)</td>
<td>15. Current concerns</td>
</tr>
<tr>
<td>17. Criticism</td>
<td>17. Disputing</td>
</tr>
<tr>
<td>18. Substantiation</td>
<td>18. Criticism</td>
</tr>
<tr>
<td>20. Similar research</td>
<td>20. Disclaiming</td>
</tr>
<tr>
<td>22. Similar research</td>
<td>22. Similar research</td>
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<tr>
<td>23. Contradictory research</td>
<td>23. Contradictory research</td>
</tr>
<tr>
<td>24. Further detail</td>
<td>24. Further detail</td>
</tr>
<tr>
<td>25. Same paper</td>
<td>25. Same paper</td>
</tr>
</tbody>
</table>

A useful distinction between social constructive and citation-analytical views could be made by addressing the general objective of each perspective as suggested by Moed (2005, p. 214-216) with reference to Zuckerman (1987), where the former perspective generally concerns itself with the motives of giving references and the latter with the consequences.

An example of this difference in perspective is found in Small’s (1978) – here representing the citation-analytic view – notion of cited documents (i.e., references) as concept symbols, where a reference is understood as a symbol of a concept/idea (e.g., experimental findings; methodologies; types of data; metaphysical notions; theoretical statements) found within the text of the cited document. Rather than examining the motives behind giving references, Small examined the extent to which the symbolic content of highly cited documents “is shared among a number of citing authors” (Small, 1978, p. 329). Small concluded that highly
cited documents tend to be interpreted as concept symbols in a “uniform” way by the citing authors/documents (Small, 1978, p. 337). Small concludes that it is reasonable to interpret high citation counts as an indication of cognitive/intellectual influence.

Another example could be that even though the motives behind a document's received citations can be rhetorical in character, (e.g., persuasion by citing an authority; to construct an argument), the use of another document as a reference for rhetorical purposes often imply that the cited document is already viewed – by other researcher in the field – as an authoritative and influential source (Moed, 2005, p. 214), or as formulated by Zuckerman (1987, p. 334): “it is peer recognition of the cognitive worth of the sources grown influential, initially reflected in high rates of citation, that makes them authoritative.”

However, social constructive and citation-analytical perspectives – the reward, rhetoric, and communication system of science (Cozzens, 1989; Kärki et al., 1998, p. 42) – are not mutually exclusive concepts, and easy to separate when it comes to the actual procedure of giving references, and further, when it comes to the actual procedure of performing and interpreting citation analysis, they should rather be understood as different aspects that – more or less – affect the results of citation based analyses (Moed, 2005, p. 215). Some aspects of citation behavior and the interpretation of citations are very difficult and/or time consuming to determine and thus to control for (e.g., to which extent a reference is actually used by the citing author; to which degree the most relevant documents are used in relation to the topic of the citing document; which references that are the more important references to a citing document in a reference list; Smith, 1981, p. 87-89). Therefore, it is important that bibliometric indicators are empirically tested and validated.

In this study received citations are interpreted as an indication of influence, not necessarily in a strict mertonian sense, but in terms of the utility of a bibliometric unit in an area of research (Garfield, 1979, p. 363). This view was applied during the interpretation of the direct citation network. While for bibliographic coupling the references in a documents reference list are understood in line with Garfield (1964, p. 652), where references represent the content of a document (e.g., method, theory, topic, etc), similar to Smalls notion of references as concept symbols, and can be viewed as a special type of subject terms or descriptors of a document. With respect to Garfields conception of the relation between references and citations as two different perspectives, rather than two separate concepts, Moed summarizes: “That, while from the point of view of the citing document a cited reference is an indicator of document content, it is from the point of view of the cited document an expression of its importance or utility” (Moed, 2005, p. 199).
Finally, I briefly point towards some empirical studies concerned with testing and validating received citations as a measure of influence and BC as a measure of topical similarity. Concerning BC, although criticized by Martyn (1964, p. 236) as to which degree BC can be considered a reliable measure of topical similarity between documents, it has been shown in later empirical studies that BC is a reliable similarity measure in the context of science mapping (e.g., Peters, Braam, & Vanraan, 1995; Vladutz & Cook, 1984). Concerning citations as an indication of influence, a number of studies, according to Zuckerman (1987, p. 330) – both within the framework of evaluative bibliometrics, and bibliometric science mapping – has shown that the results from citation analysis are positively correlated with the results of other qualitative methods such as peer judgment to assess intellectual influence, utility or impact (e.g., McAllister, Anderson, & Narin, 1980; Small, 1977).

3.5 Timeline visualization of research specialties

The structure of science can be described in terms of a hierarchy consisting of disciplines (e.g., psychology), sub-disciplines (e.g., sport and exercise psychology), and specialties (e.g., motivation research within sport and exercise psychology) etc. Motivation research in SEP – the object of analysis – is in this study understood within the theoretical framework of research specialties as suggested by Morris and Martens (2008). The term research specialty refers to (Morris & Martens, 2008):

[...], a self-organized network of researchers who tend to study the same research topics, attend the same conferences, read and cite each other’s research papers and publish in the same research journals. A research specialty produces, over time, a cumulating corpus of knowledge, embodied in educational theses, books, conference papers, and permanent journal literature. Members of a research specialty also tend to share and use, to some degree, a framework of base knowledge, which includes knowledge of theories, experimental data, techniques, validation standards, exemplars, worrisome contradictions, and controversies. (p. 213-114)

The research specialty constitutes a theoretical framework to understand the scientific unit that was mapped in this study by analyzing its FSC. Morris and Boyack (2005), and Morris, Yen, Wu, and Asnake (2003) has developed a technique based on timelines to analyze and visualize the temporal changes in a research specialty. A variation of this analysis and
visualization technique is adopted in this study. Two important aspects concerning the longitudinal mapping procedure of timeline visualization is the concepts of the intellectual base and research fronts of a scientific research area. In general, a research front in science refers to some particular line of research within an area of research. According to Persson (1994, p. 31), a research front consist of articles that cites the same literature (i.e., share intellectual base; are bibliographically coupled) and the intellectual base consist of the literature cited by the research front. In timeline visualizations the specialty is subdivided into a number of research fronts, which in this context refers to “groups of papers that tend to cite common references. Such groups of papers tend to cover a common research sub-topic in the specialty (Morris & Boyack, 2005, p. 45). By plotting research fronts in timelines, the appearance and disappearance, as well as the dynamics and structural information of the research fronts within a research specialty can be obtained (Morris et al., 2003, p. 415).

Figure 2 presents a model of the process of FSC in a research specialty. The model consists of a group of researchers that share research interests and that constitutes a social network, their intellectual base, i.e., the literature they cite, and their published literature (i.e., the research fronts of their area of research).

**Figure 2. Model for the process of FSC within a research specialty (modified from Morris and Van der Veer Martens (2008, p. 240))**

Figure 1 is commented below (Morris & Martens, 2008, p. 240-241):

- The intellectual base, refers to the intellectual framework or knowledge base (i.e., the older literature that the researchers read and cite in order to produce new research) that the researchers within the research group share with each other. The intellectual base contains the most important sources that are used within the given group of researchers, such as theories, methodologies, empirical studies and so forth.
• *Researchers*, refers to the social network of researchers that constitutes the given area of research.

• *Published literature*, refers to the accumulation of formal documents that are produced and published by the group of researchers. For example, peer reviewed articles, proceeding papers, dissertations, books and monographs'. It is this accumulation of documents that constitutes the object of study when analyzing research fronts. Over time the highly cited/used publications is integrated as parts of the intellectual base within the given research area.

4. **Methods**

4.1 **Basic concepts**

The construction of a research front timeline consists of a number of steps. In this study I followed a sequence proposed by Morris et al. (2003, p. 415-416):

1. Field delineation and data collection.
2. Remove outliers (i.e., articles that are not well integrated in the article set in terms of BC-counts)
3. Calculating similarities between all remaining articles in the dataset with normalized bibliographic coupling.
4. Applying cluster analysis to the network based on normalized bibliographic coupling.
5. Timeline visualization of research fronts.

The first part of this section introduces the most central methodologies in this study. The second part consists of descriptions of the actual procedures.

4.1.1 **Field delineation and data collection**

In bibliometric science mapping, field delineation refers to “the process of collecting a set of bibliographic records with cited-reference information of research articles that represent a research field” (Strotmann & Zhao, 2010, p. 194). This process is usually the first step in bibliometric science mapping studies.

The delineation of motivation research within the field of SEP was in this study conducted within the broad framework of the hybrid “lex + cite” method as suggested by Laurens, Zitt, and Bassecoulard (2009, p. 647-649), where collaboration with, and supervision of, subject
experts is a central part of the different steps in the delineation process. The lex + cite method consists of a mix of methods related to bibliometrics and information retrieval. These methods are applied in a series of steps and draws upon different aspects of the information in bibliographic records such as: linguistic content; cited references; and other kinds of metadata (e.g., journal name) (Bassecoulard, Lelu, & Zitt, 2007a, p. 75). The lex + cite method was developed to (1) deal with complex, emerging and highly interdisciplinary fields where traditional method of field delineation – such as the operationalization of a field by means of a selection of core journals (White & McCain, 1998, p. 330) – would not work well, and (2) to deal with limitations and biases related to specific methods by adding complementary strategies to the delineation process, for example citation based extension as a strategy to reduce the inherent risk of specialization effects (i.e., subjective biases), in the selection of core journals or keywords for lexical queries. Given the interdisciplinary and applied character of motivation research in SEP the lex + cite method seemed to be an appropriate method for this study. A brief sketch of the different steps in the hybrid lex + cite method could be described as follows (Laurens et al., 2009, p. 648):

1. The process begins – for example – with a selection of core journals and the creation of a lexical query for a topical search to retrieve a core set of relevant documents in collaboration with subject expert
2. The core set is expanded by citation based extension, where – for example – articles citing the core set is identified and added to the core set
3. A cluster analysis is performed on the expanded set in order to evaluate and refine the delineation in collaboration with subject expert.

With respect to the relative success of the process, each step can be iterated given the interests at hand.

4.1.2 Bibliographic coupling

Bibliographic coupling (BC) is a central measure in this study. It is used in the cluster analysis for the identification of research fronts, but also as a similarity measure in some of the procedures in the field delineation process and in the structuring of the timeline visualization.

BC is a measure of topical similarity between documents based on shared references. If two documents cites the same source they are bibliographically coupled. The strength of a relationship based on BC is determined by the number of cited references two documents
share in their reference lists, the more cited references they share, the more similar they are assumed to be with respect to subject content (Persson, 1994, p. 31).

In order to calculate the BC strength (i.e., the degree of similarity) between bibliographically coupled documents in terms of the number of shared references, an asymmetric $n \times m$ reference-by-document matrix is used, where the columns consist of citing documents and the rows of cited references. By summing across the columns a row total indicating the number of times a cited reference occurs in the citing documents is obtained, (i.e., how many times a document in the intellectual base is cited by document in the research fronts), and by summing across the rows a column total is obtained indicating the number cited references contained in an individual document (i.e., the length of the reference lists in the citing documents). The coupling strength (i.e., the number of shared references between two documents) is obtained by calculating the dot product of two columns (Persson, 1991, p. 69-70). See Figure 3 for an example of an asymmetrical reference-by-document matrix.

**Figure 3. Example of a reference x document matrix, modified from Persson (1991, p. 69).**

<table>
<thead>
<tr>
<th>Cited references</th>
<th>Citing documents</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>l</td>
</tr>
<tr>
<td>...</td>
<td>R_{ij}</td>
</tr>
<tr>
<td>m</td>
<td>R_{mi}</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
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<td>...</td>
<td>...</td>
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<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>n</td>
<td>...</td>
</tr>
</tbody>
</table>

Furthermore, in analyses based on bibliographic coupling it is assumed that the strength of the cognitive relationship or similarity between two citing documents should be normalized with respect to the length of the reference lists containing the cited references by calculating a normalized bibliographic coupling strength (Olle Persson, 1991, p. 71). A commonly used measure to normalize the bibliographic coupling strength with respect to the length of reference lists is Salton’s cosine. Salton’s cosine was also used in this study to calculate the normalized coupling strength (NCS$_{ij}$) and can be defined as...
where \( r_i \) denotes the number of references in the reference list of document \( i \); \( r_j \) the number of references in document \( j \); and \( r_{ij} \) the total number of shared references between document \( i \) and \( j \). The normalized coupling strength is calculated by dividing \( r_{ij} \) with the squared root of \( r_i \) and \( r_j \) multiplied with each other (Salton & McGill, 1989, p. 121-122). With Saltons cosine, shared references are normalized with respect to the total amount of references contained in the bibliographically coupled documents reference lists. Given that two articles share the same amount of references as another pair, the pair with the shortest reference lists receives a higher normalized coupling strength (Salton & McGill, 1989, p. 203). From now on normalized coupling strength refers to Saltons cosine as defined above.

4.1.3 Cluster analysis
Cluster analysis is an umbrella term for a set of statistical techniques developed to cluster objects into groups on the basis of similarities or dissimilarities (Kaufman & Rousseeuw, 2005, p. 1-2). In this study I used the cluster analysis method Partitioning around medoids (PAM) to identify subject coherent research fronts in the article set between 1985 and 2009. PAM is based on a cluster algorithm that falls within the framework of partitioning methods. A partition method classifies the data into \( k \) groups or clusters (i.e., the number of groups is predetermined by the user) given two basic conditions: (1) that every cluster contains at least one object, and (2) that every object is classified to only one cluster (i.e., that the partition consists of mutually exclusive groups) (Kaufman & Rousseeuw, 2005, p. 38). The aim of partitioning methods is to find a “good” partitioning given the predetermined \( k \) of clusters. A good partition is generally defined as consisting of clusters where “objects of the same cluster should be close or related to each other, whereas objects of different clusters should be far apart or very different” (Kaufman & Rousseeuw, 2005, p. 39).

In order to obtain \( k \) clusters with PAM, the cluster algorithm first selects as many so-called medoids (i.e., representative objects) in the data set as the chosen \( k \) for the partition. The algorithm then build clusters around these medoids by assigning all the remaining objects to their closest (i.e., most similar) medoid. The selection of medoids is iterated until the
“average dissimilarity of objects to their closest representative object” (Kaufman & Rousseeuw, 2005, p. 102) is minimized.

### 4.1.3.1 Determining $k$ of clusters

A difficult task in cluster analyses is to determine the number of clusters to obtain. There is no unique solution to this problem (Kaufman & Rousseeuw, 2005, p. 87). The appropriate $k$ depends on the characteristics of the data set and the aim of the study. With PAM a good partition with $k$ clusters is obtained when the criterion of minimized average dissimilarity is fulfilled. In this study I used silhouette curves with average silhouette values of every partition of the data set in order to compare the relative quality of different partitions as a guide for choosing the $k$ of clusters (Janssens et al., 2007, p. 364; Kaufman & Rousseeuw, 2005, p. 83-84).

The silhouette width is a measure of cluster quality in terms of how similar each assigned object is to its own cluster in comparison with its similarity to other clusters. Clusters with high average silhouette widths (i.e., clusters with many objects that are much more similar to their own cluster, than to other clusters) are considered well pronounced clusters. Based on the average silhouette width of all clusters in a partition the average silhouette width for the entire data set can be obtained. Further, by calculating the average silhouette widths for all possible $k$ given the total data set at hand, one can select an optimal number of clusters by choosing the $k$ with the highest average silhouette width (Kaufman & Rousseeuw, 2005, p. 83-84).

### 4.2 Procedure

#### 4.2.1 Retrieving a core set of articles

To delineate motivation research in the field of SEP the first step consisted of collecting a core set of relevant articles that could be expanded by citation based extension. Due to the longitudinal character of this study the citation indices of Thomson Scientific through Web of Science (WoS) was used for data collection. Initially I elaborated with the creation of a lexical query based on keywords provided by subject experts and restricted it to a topical search within six core journals (see Table 2). Some journals have delayed indexing dates in WoS compared to the starting point of the journal (Table 2). It would of course be optimal if the indexing dates corresponded with the start of the journals. However, the citation indices of WoS is the only databases where the bibliographic data needed for citation-based analyses are
indexed as far back as needed in this study, and given the condition that a complete data set would be impossible to collect, it was assumed that with the citation-based extension, a data set representative of the specialty of motivation research within the field of SEP could be obtained.

Table 2. Start year, and start of indexing year in WoS, of the six core journals.

<table>
<thead>
<tr>
<th>Journal</th>
<th>Start year</th>
<th>WoS</th>
<th>PSYCH-info</th>
<th>SPORT-discus</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Sport Psychologist (SP)</td>
<td>1987</td>
<td>1993</td>
<td>1987</td>
<td>1987</td>
</tr>
</tbody>
</table>

The restriction of core journals was set due to the interdisciplinary and applied character of motivation research in SEP. However, the lexical query based approach proved to be difficult for a number of reasons: (1) even with the restriction of core journals it was very difficult to discriminate between relevant and non-relevant articles given the definition of motivation research within SEP in this study; (2) a large amount of the bibliographic records connected to articles published pre-1995 only contained the title field and lacked the abstract and keyword fields. As a consequence, even with a nominalistic query – with only “motivation” as search term\(^6\) – relevant articles published pre-1995 that did not contain the word motivation in their title would not be retrieved. Therefore, with the lexical query approach the distribution of the number of retrieved articles was likely to be much skewed towards the time period post-1995; (3) due to the lack of abstracts in the pre-1995 period it was very hard to determine whether the articles retrieved from that time period was relevant for this study. The delineation of motivation research in SEP can be considered a field delineation process on the micro level, with focus on precision rather than recall, and as such it was important to be able to evaluate the articles in step 1 so that the core set could be properly refined to relevant articles for the expansion in step 2.

\(^6\) A more “open” query than this one, with some more keywords connected by or operators, would retrieve to much noise, and a more restricted query would of course retrieve less articles (increase silence).
To address these problems a multi-database approach with controlled vocabulary, as suggested by Strotmann and Zhao (2010a), Strotmann and Zhao (2010b), and Strotmann, Zhao, Bubela, Larsen, and Leta, (2009), was used instead of the lexical query approach. The idea of the multi-database approach is basically to use the controlled vocabulary of a bibliographic database to identify a representative set of articles and then to identify and retrieve this set of articles in a citation index to obtain the cited references needed to perform citation based analyses (Strotmann & Zhao, 2010a, p. 195-198).

The multi-database approach involved several steps. Initially, two relevant bibliographic databases were identified in collaboration with a subject expert. PSYCHINFO and SPORTdiscus, the two largest bibliographic databases within the frameworks of psychology and sport were chosen. I used two databases to address the problem of the “indexers effect”: inherent biases in controlled vocabularies due to human errors in the process of subjectively indexing documents by subject matter (Law & Whittaker, 1992, p. 422; Rowley, 1994, p. 112-113). These two databases was chosen based on the following criterias: (1) that they were topically relevant and was recognized within the field; (2) that all six core journals was indexed at least from 1980 or from the starting point the journal; (3) that they had a controlled vocabulary, thesauri or subject heading list; (4) that most of the bibliographic records contained abstracts.

PSYCHINFO and SPORTdiscus were accessed through EBSCOhost. Here I use the PSYCHINFO database to describe the multi-database procedure where motivationally oriented SEP articles was identified and then retrieved in WoS (concerning SPORTdiscus, all relevant results will be presented in the end of this section).

First, a search was made on the following thesaurus subject headings in PSYCHINFO: “Motivation”; “Intrinsic Motivation”; “Extrinsic Motivation”; and “Achievement Motivation”. The search was refined to the 6 core journals, to journal articles and to the years 1970-2009. From this search 388 articles were retrieved. The retrieved article set was semi-automatically “cleaned” with respect to duplicate records and signs and symbols that did not work well in the search engine of WoS, for example question marks and exclamation marks.

Next step involved the matching of the bibliographic records retrieved from PSYCHINFO with their counterparts in WoS. Strotmann and Zhao (2010b, p. 268-269) compare Scopus and WoS for matching bibliographic records. The results showed that while Scopus support the construction of complex queries with high precision and recall, the process of retrieving

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7 These were the only relevant subject headings available in PSYCHINFO.
matching records in WoS was much more difficult and time consuming (Strotmann & Zhao, 2010b, p. 268-269), mainly because the field tags “issue”, “pagefirst” and “pagelast” was searchable in Scopus, but not in WoS. However, while experimenting with different strategies and queries in WoS, two “hidden” or “unofficial” searchable field tags were identified: “volume”, VL=; and “pagefirst”, PG=. With the identification of these two field tags it was possible to create a query in WoS similar to the query suggested by Strotmann and Zhao (2010a, p. 196) for matching articles between databases in Scopus. Thus, to match the articles retrieved from PSYCHinfo with their counterparts in WoS a search string for every article was constructed. Each individual search string looked for the journal name or the ISSN-number, for the publishing year or volume, for the starting page numbers, and for the authors last names or the title of the article. The structure of the search strings looked like this:

(SO="Psychology of Sport and Exercise" OR IS=1469-0292) AND (PY=2009 OR VL=10) AND PG=255 AND ((AU=(Stuntz AND Weiss) OR (TI="Achievement goal orientations and motivational outcomes in youth sport: The role of social orientations.")))

Every search string ($N = 388$) was assembled in one query and a search was conducted in WoS. The search retrieved 366 documents published between 1974 and 2009, from now on referred to as the WoS set. 353 of these documents were articles.

To evaluate the quality of the retrieved set with respect to how well the query succeeded in matching the bibliographic records from PSYCHinfo with their counterparts in WoS, false positives (i.e., records in the WoS set that did not have a counterpart in the original PSYCHinfo set) was identified, as well as unidentified records (i.e., bibliographic records that were in the original PSYCHinfo set, but was not retrieved with the query) (Strotmann & Zhao, 2010a, p. 197-198). An IF-formula$^8$ was created in Excel for identification of false positives in the WoS set ($N = 366$). The criterias for matching the bibliographic records was: ISSN + VOLUME + ISSUE + BEGINNING PAGE. According to the stated criteria no false positives could be identified. Next, a procedure similar to the false positives procedure was set up for the identification of unidentified records. The purpose of this procedure was to identify unidentified records and search for these in WoS. 22 unidentified records were found. 16 of these were published before the journals had been indexed and could not be retrieved in WoS, the six remaining records were searched in WoS by looking for ISSN, publishing year

$^8=$IF(ISERROR(MATCH(A2;$CS$2:$CS$366;0));"NULL";A1)
and up to three authors as suggested by Strotmann and Zhao (2010b, p. 268-269). Four of these six records could be retrieved. Given the discrepancy of the index time of the core journals between PSYChINFO and WoS, the total number of relevant records was 372, which gives a recall of 99.5%, and a precision of 100%. With respect to this evaluation it seems like the construction of complex queries for matching records from bibliographic databases with records in WoS works quite well, which is promising, at least given the dataset at hand, and that the “hidden” fieldtags: VL= and PG= is used.

Finally, the 353 articles retrieved with the initial query were combined with the 4 unidentified records retrieved in the second search, adding up to a final PSYChINFO set with a total of 357 articles.

A similar procedure was conducted with respect to the SPORTdiscus database. A difference between the two databases was the “messiness” of the indexing and bibliographic records in SPORTdiscus compared to PSYChINFO. The retrieved SPORTdiscus set contained a large amount of duplicate records and many irrelevant document types (i.e., non-journal articles) such as: abstracts; poster session; research notes; and other supplements. The main steps/results from the SPORTdiscus procedure are listed below:

- The following thesaurus subject headings were searched: "MOTIVATION (Psychology)”; "ACHIEVEMENT motivation”; and "INTRINSIC motivation”, and refined to
- the six core journals and “journal article” between 1970-2009
- This search retrieved 895 bibliographic records
- After duplicates and non “journal article” records were removed and the query for WoS was created, 423 articles published between 1974 and 2009 could be identified and retrieved from WoS.

To conclude, the final PSYChINFO set consisted of 357 articles and proceedings papers and the final SPORTdiscus of 423 articles and proceedings papers. Two queries were created based on the UT-field in the WoS records and a search was conducted in WoS. Both sets could be fully retrieved. Combined the two sets added up to 532 articles published between

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9 Recall is here defined as to which extent a given query manages to retrieve relevant records with respect to the total amount of relevant records, and has been calculated by dividing the “Number of relevant items retrieved” by the “Total number of relevant items in the collection” times 100. Precision is defined as to which extent the retrieved records are relevant to the query, and has been calculated by dividing the “Number of relevant items retrieved” with the “Total number of items retrieved” times 100 (Chowdhury, 2010, p. 286).

10 To generalize these results a more thorough study with a larger dataset would be required.
1974 and 2009. With an overlap of 248 articles between the sets, they were – as expected, with reference to the “indexer effect” – quite complementary to each other.

To evaluate the multi-database approach with respect to the problem with a skewed distribution of articles over time when using a lexical query approach in WoS (i.e., with respect to which degree the multi-database approach was able to increase the amount of pre-1995 articles) I compared the number of retrieved articles from a nominalist lexical query containing only the search term “motivation*” within the six core journals (retrieving $N = 785$ articles), with the number of retrieved articles for the same period of time with the multi-database approach. The lexical query retrieved 35 articles between 1974 and 1989 and the multi-database approach retrieved 160 articles, when the overlap was removed, the total amount of pre-1995 articles increased by 125 articles (357%) with the multi-database approach using controlled vocabulary. This was considered a satisfying result.12

With a potentially final core set at hand, the combined set of PSYCHinfo and SPORTdiscus ($N = 532$) was prepared for subject expert evaluation and refinement. The preparation involved two steps. First, abstracts from the combined set of PSYCHinfo and SPORTdiscus records were matched to the combined set retrieved in WoS. There was a total lack of abstracts between 1974 and 1991 in this set. In a comparison between the pre- and post-1995 time periods, abstracts were missing in 62% of the pre-1995 records and in 2% of the post-1995 period. The abstracts were matched with the WoS records based on the following criterias: ISSN + VOLUME + ISSUE + BEGINNING PAGE. A total of 125 records in the combined PSYCHinfo and SPORTdiscus WoS set lacked abstracts. 120 of the 125 articles could be matched with an abstract. Secondly, in order to ease evaluation and refinement a cluster analysis was applied to the final core set (Laurens et al., 2009, s 656-557). On the basis of normalized BC the hierarchical agglomerative cluster analytic method average linkage was used to cluster the articles in subject coherent groups following the procedure in (Lindahl, 2011, s 25-27). In order to partition the clustering (i.e., to determine the number of clusters to obtain), I used an arbitrary threshold of 0.985 aiming for a fairly small number of clusters as suggested in (Bassecoulard, Lelu, & Zitt, 2007b, p. 865; Laurens et al., 2009, p. 657). The cluster analysis resulted in 52 clusters. Due to the character of the specialty of motivation research in SEP, I aimed for precision, rather than recall in the delineation phase. The clusters,

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11 TS=(motivation*) AND SO="(sport psychologist" OR "journal of sport psychology" OR “International Journal of Sport Psychology” OR “Journal of Applied Sport Psychology” OR “Journal of Sport & Exercise Psychology” OR “Psychology of Sport and Exercise”)

12 However, this comparison did not take the relevance of the retrieved articles in consideration, only the number of retrieved articles.
containing 532 bibliographic records, were thus handed to a subject expert for evaluation and further fine tuning of the core set. The subject expert identified 125 articles that did not fit the definition for motivation research within SEP in this study, these articles were removed resulting in a clean core set containing 407 articles.

4.2.2 Citation-based extension

The procedure of citation-based extension of the core set ($N = 407$) served two, partly overlapping purposes:

1. To identify topically relevant articles and add these to the core set in order to obtain a more representative data set.
2. To compensate for potential weaknesses with controlled vocabularies (i.e., the indexer effect), such as: low recall, human errors and subjectively related biases in the indexing process (Law & Whittaker, 1992, p. 422; Rowley, 1994, p. 112-113).

All articles that cited at least one article in the core set (published 1974-2009) was identified in WoS with the Create citation report function. This procedure generated an extended set of 2701 articles (core set duplicates excluded) that potentially could be added to the core set. In order to determine which of these 2701 articles that were topically similar to the articles in the core set, and in that sense likely to be relevant for this study, a measure of topical similarity between the articles in the core set and extended set was required, as well as a method to evaluate the similarity between these articles at different thresholds so that a particular threshold could be chosen.

Naturally, direct citations was used as similarity measure, but given the complexity of motivation research in SEP and the difficulties in discriminating between relevant and irrelevant articles in earlier stages of the delineation process, a variation of weighted direct citations (WDC) as suggested by Persson (2010) was used to obtain a more powerful and fine grained measure of similarity. WDC is based on the assumption that the strength of a direct citation relationship in terms of similarity between the documents is stronger if they also share indirect citation links such as bibliographic couplings and co-citations. The WDC strength is calculated by adding the number of BCs and co-citations shared between the citing document and the cited document in a direct citation relationship, where $1 \text{ DC} + 1 \text{ BC} + 1 \text{ co-citation} = 3 \text{ WDC}$ (Persson, 2010, p. 415-416). Here, I weighted the direct citations with BCs, aiming for articles that have a direct citation relationship but also share intellectual base. See Figure 4, for an overview of the variation of WDC used in the delineation process in this study.
Given the variant of WDC used here, two parameters for adjusting the thresholds to obtain relevant articles from the extended set were used. Parameter (1) was the number of articles in the core set that an article from the extended set cited. Parameter (2) was the number of BCs between the citing article in the extended set and the cited article in the core set.

**Figure 4. The DC link between A and B, where B cites A is strengthened because they both also cite C (modified from Persson (2010)).**

Thus, it was assumed that the likelihood that an article from the extended set was topically relevant for this study increased if this article cited many articles in the core set and at the same time shared many references with these cited articles.

In order to choose a suitable threshold based on these two parameters, *median pair-wise word profile similarity* (MPWPS) was calculated within the core set and between the core set and the extended set (Lindahl, 2012). The preparation for, and calculation of, MPWPS consisted of three steps:

- First, in the extended set 264 articles lacked abstract and in order to maximize the quality of the MPWPS – that were based on titles and abstracts – the missing abstracts was manually identified and retrieved from PSYCHinfo; PsychARTICLES; SPORTdiscus; MEDLINE; and Academic Search Elite. 206 abstracts could be identified and matched to the WoS records in the extended set.
- Secondly, word profile similarity between all articles, the core set as well as the extended set, was calculated (Braam, Moed, & Van Raan, 1991, p. 236-237). Word profile similarity between articles (or lexical coupling) is in principle the lexical counterpart to document bibliographic coupling, where the similarity between
documents is based on shared words instead of shared references. All terms were extracted from the titles and abstracts from each article in the core and extended set and a word profile (i.e., a list containing content words) was created for every article. The text pre-processing involved the removal of stopwords (Stopwordlist 1, 2012) and the removal of all characters except numbers and letters, together with all words with fewer than two letters. Furthermore, the Porter algorithm for stemming (Porter, 1980) that is implemented in Bibexcel (Persson, Danell, & Wiborg Schneider, 2009) was applied to the word profiles in order to reduce mismatches between words due to different suffixes. The word profiles were weighted by term frequency-inverse document frequency (TF-IDF). TF-IDF is a weighting scheme commonly used in information retrieval to evaluate how important a word is to a document within a specified set of documents, where the importance of a word increases in proportion to the number of times a word occurs in a document and decreases in proportion to the number of times a word occurs in the set as a whole (Baeza-Yates & Ribero-Neto, 2011, p. 72-75). Then the similarities between the articles based on the weighted word profiles were obtained by the application of Salton’s cosine.

• Thirdly, in order to determine and compare the MPWPS within the core set with the MPWPS between the core set and the extended set, a Wilcoxon rank-sum test (equivalent to the Mann-Whitney-Wilcoxon test) was applied. The Wilcoxon rank-sum test is a nonparametric test by which the median of two distributions can be compared at a 0.05 level of significance (Woodbury, 2002, p. 615-625). In the context of word profile similarity between articles the Wilcoxon rank-sum test indicates to which degree the central tendency, in terms of the median, is larger, smaller or equal within the core set and/or between the core set and extended set. Thus, indicating to which degree the two distributions are similar or dissimilar to each other.

In order to set a threshold based on MPWPS I started by comparing the MPWPS within the core set with the MPWPS between the core set and the extended set. This test showed that the MPWPS was significantly higher (P < 0.05) within the core set than between the core set and the extended set, indicating that the extended set contained articles that were not topically similar to the articles in the core set. To remove these potentially irrelevant articles I raised the threshold by 1 DC to the core set and 2 BCs with the cited article in the core set step by step and tested the MPWPS at every threshold until the Wilcoxon rank-sum test either showed that the within-MPWPS was equal to or smaller than the between-MPWPS. If a threshold
showed that the within-MPWPS was smaller than the between-MPWPS. I followed the principle of binary searching (Cormen, 2001, p. 37) in order to manually trace back to the threshold where the two distributions were significantly similar (P > 0.05) with respect to the median. This procedure resulted in a threshold – three DC, where each DC had a weight of five BC – by which 461 articles was extracted from the N = 2701 extended set. As with the core set, this article set was clustered with the hierarchical agglomerative method average linkage based on normalized BC. With an arbitrary threshold of 0.96 the partition resulted in 29 clusters. Further, this cluster solution was handed to a subject expert for evaluation and further fine tuning.

The subject expert could identify 88 articles that did not fit the definition of motivation research within SEP used in this study. These articles were removed from the extended set resulting in a final extension of 373 articles published in 104 different journals (including the 6 core SEP journals). The core set and the extended set was combined to a data set containing: 407 (core set) + 373 (extended set) = 780 articles, published between 1974 and 2009. Furthermore, all articles published prior to 1985 (n = 41) was removed from this set, resulting in a final set of 739 articles representing motivation research within SEP during 25 years, between 1985 and 2009. The time period of 1985-2009 was chosen on the basis of the amount of retrieved articles.

4.2.3 Identifying research fronts

With a final dataset of 739 articles the data was prepared for the cluster analysis. First, a threshold was set to remove articles that were not well integrated in the data set in terms of BC-counts (i.e., outliers in the data set) in order to increase the possibilities of producing meaningful cluster on the basis of this article set. Articles that did not have at least 5 BCs with another article in the data set were removed as suggested by Morris et al. (2003, p. 416). With this threshold the total number of articles was reduced to 610. The reference string from every article was extracted and standardized in order to reduce the effects of mismatches between identical references due to spelling variants etc. A routine used in Lindahl (2011, p. 26) was applied, where every reference string was reduced to the six first characters in the authors last name, the first initial, publication year, volume, beginning page, and publication type. Secondly, a matrix containing the normalized BC-counts was produced. This process involved the following steps:
1. The cited references in the $N = 610$ article set was extracted and converted into asymmetric $n \times m$ reference-by-article matrix.

2. The asymmetric $n \times m$ matrix containing the reference strings from every article in the data set was transformed to a symmetric $n \times n$ similarity matrix containing normalized BC-strength between every article in the data set.

The research fronts were identified with the cluster algorithm PAM. PAM is built to handle dissimilarities between objects, therefore the similarity matrix containing the normalized BC-strength was transformed into a dissimilarity matrix by taking $1 - \text{the similarity-value}$. Thereafter PAM was applied to the dissimilarity matrix.

4.2.3.1 Choosing $k$ clusters

In order to determine the number of clusters, the average silhouette for every possible $k$ in the data set was calculated and plotted in a diagram. Further, an inspection of the silhouette curves was conducted aiming for a local maximum as suggested by Janssons, Glänzel, and De Moor (2007, p. 364). A local maximum yielding $19k$ was chosen. As can be seen in Figure 5 another choice could have been the second local maximum with a $10k$ partition, or a larger $k$ that would yield a higher average silhouette and therefore a more optimal clustering solution with respect to a strictly formal criteria of maximizing the silhouette value. However in this study I was aiming for a slightly more fine grained research front timeline than $10k$ as suggested in Morris and Boyack (2005, p. 46-47), but not a $40+$, $60+$ or $90+$ clustering solution – that of course would generate a higher average silhouette – but not a comprehensible overview of motivation research in SEP (see Figure 5). The $19k$ solution was handed to a subject expert for validation and classification of every cluster according to research theme, based on some common denominator across the included articles (e.g., a theory, a topic, etc.)
Figure 5. The first 100 average silhouette values based on 610 articles. Y-axis show average silhouette values, X-axis show number of clusters. Arrow show local maximum of 19 clusters.

4.2.4 Visualizing the development of motivation research in sport and exercise psychology

Two timeline visualizations was created: timeline visualization I displays publication frequencies, indicating changes in terms of productive sub areas and their research themes over time, and timeline visualization II displays direct citations (information flow) between the timeslices within the different research fronts. The timeline visualizations was created as variants of the model proposed by Morris and Boyack (2005) and Morris et al. (2003) where each timeline consists of a coordinate system where the y-axis denotes research fronts (i.e., clusters), while the x-axis denotes four timeslices between 1985-1994, 1995-1999, 2000-2004 and 2005-2009.
Bibexcel (Olle Persson et al., 2009) was used to preprocess and analyze the bibliographical data used for the timeline visualizations. The actual visualizations were created in Pajek (De Nooy, Mrvar, & Batagelj, 2011) and post processed in a vector based program for graphics.

4.2.4.1 Timeline visualization I: Publication frequencies and research front topics

Initially, in order to place similar research fronts (i.e., research fronts that share intellectual base) close to each other in the timeline visualization a principal component analysis (PCA) aggregated to the research front (i.e., cluster) level ($N = 19$) was conducted on BC counts between all articles in the data set. First, the reference strings from all articles in the data set was standardized so that every author name contained only one initial to reduce spelling variants. Then BC counts between all articles in the data set was calculated and aggregated to the level of research fronts according to which research front they belonged with respect to the cluster analysis. A $19 \times 19$ similarity matrix was constructed containing the raw BC strength between every research front. Then a PCA was applied to the $19 \times 19$ similarity matrix in accordance with the tradition of author co-citation analysis (e.g., McCain, 1990; White & McCain, 1998).

PCA is a dimensionality reduction technique where the aim is to transform a large data set of correlated variables (i.e., research fronts) into a smaller set of uncorrelated variables called principal components (PCs), while maximizing the variance (i.e., minimizing information loss) in the data set (Jolliffe, 2002, p. 1). The PCA was conducted in line with McCain (1990) and Zhao and Strotman (2008), with an oblique rotation (direct oblimin in SPSS) that resulted in a three component model explaining 88.6 percent of the variance in the data set. The diagonals were treated as missing values and replaced by means as suggested by McCain (1990) and in order to determine the number of components to retain, I used Kaiser’s rule with eigenvalues larger than one (Kaiser, 1960). The PCs were then ordered along the y-axis in the visualizations after their correlations in the component correlation matrix from the PCA output so that PCs with high correlations were placed near each other. By structuring the research fronts in this manner, the clarity and overview of the visualized direct citation network was considerably enhanced.

Even though all research fronts could be classified, the specificity of the classification differed, and some research fronts could only be classified in quite a general manner (e.g., Self-determination theory 1; Self-determination theory 2; Self-determination theory 3, etc.). This phenomena of clusters with non-differentiating research front labels have also been found in previous studies (e.g., Morris et al., 2005, p. 49-50). The reasons behind this
phenomena lies beyond the objectives of this study, but will be briefly discussed in section 5. Results and discussion. However, to address the phenomena of non-differentiated research front labels and potentially be able provide a more fine grained and differentiated view of the subject content of the research fronts I elaborated with a variation of the keyword network visualized by Janssens, Glänzel, and De Moor (2007, p. 4-5), where TF-IDF weights was calculated for all author keywords in an article set and then, based on a threshold, a limited number of keywords was chosen and visualized as a network.

Due to the longitudinal perspective and the relatively small data set used in this study author keywords could not be used. Instead keyword profiles based on titles and abstracts from the 610 articles were created with rapid automatic keyword extraction (RAKE), a keyword extraction method by which stop words, phrase delimiters and word delimiters are used as input parameters to extract a set of candidate keywords from each individual document in the dataset, furthermore scores for each candidate keyword are calculated by means of a graph theoretically based metric, for computational details see (Rose, Engel, Cramer, & Cowley, 2010). The actual keywords are then chosen on the basis of a threshold. A keyword can be defined as “a sequence of one or more words, [that] provide a compact representation of a document’s content” (Rose et al., 2010, p. 3). A nice feature of RAKE is that it allows for single words to appear in different semantic contexts, thus producing keywords with much higher degree of contextual specificity than keyword extraction based on single words.

Initially a threshold was set for the number of keywords to include in the keyword profiles that would subsequently be weighted with TF-IDF. I elaborated with a number of thresholds. After manual inspection and subjective comparison, the top 60 percent, with respect to the RAKE keyword scores, were chosen. This threshold seemed to balance nicely between meaningful keywords and subject matter specificity with respect to the individual research fronts.

In order to enhance the quality of the keyword extraction three groups of additional stopwords was added to the selected stopword list: (1) the top hundred authors with respect to published articles was extracted from the article set and added due to references to many of these authors in the abstracts, (2) non-meaningful terms and abbreviations associated with scientific publications and bibliographical data such as et, al, psychinfo, vol, and symposium was added, as well as (3) non-meaningful terms associated with the process of scientific inquiry such as confirmed, revealed, purpose, and examined.

Before applying TF-IDF, the RAKE keyword profiles were aggregated to the level of research fronts ($N = 19$). In the preprocessing phase all numbers and non a-z characters were
removed, as well as all words with less than two characters. Then the top five keywords, with respect to TF-IDF scores, were selected from every aggregated research front keyword profile. Even though a filter of added stop words was used the results had to be manually inspected in order to identify and remove non-meaningful keywords such as: names (e.g., author names, country names); keywords associated with specific sports (e.g., competitive swimmers, soccer); and non-meaningful vocabulary associated with the publication process and scientific inquiry that was not filtered away by the added stop words (e.g., outlined, main effect, strongest predictors).

As a consequence of the contextual specificity of the extracted RAKE keywords it was quite common that more than one keyword among the top ten had the same TF-IDF score. In cases when this made the TF-IDF score useless for determining the top five, the keyword(s) with the highest (total within research front) candidate keyword ranking, according to the RAKE keyword scores, was chosen. At least on a theoretical basis, the TF-IDF weighting scheme could be expected to identify (potentially) specific and coherent “sub-themes” based on vocabularies within the research fronts, which otherwise would be difficult and time consuming to identify.

All top five keywords (a total of 86 unique keywords) within the 19 aggregated RAKE keyword profiles were assembled in an 86×19 asymmetrical keyword-by-“research front” matrix containing the TF-IDF values. A threshold was set so that only lines with TF-IDF scores ≥ 2 are shown in order to make the network less dense. The width of a line shows the importance of a keyword to a research front. The size of research front nodes indicates the total number of publications, and the size of keyword nodes indicates in-degree (i.e., total number of connections). Top five keywords with lower TF-IDF values than two are still shown in the network, these keywords are represented with dotted lines.

4.2.4.2 Timeline visualization II: direct citation network

Based on the same layout as timeline visualization I, timeline visualization II show DCs between research front timeslices. DCs was identified between all 610 articles in the data set and aggregated to the level of timeslices (N = 62).

A threshold of ≥ 15 DCs was set to reduce the density of the directed network so that only strong links would show. The width and grey scale strength of the directed and connecting lines indicate citation frequency between a citing and cited timeslice. The size of timeslice nodes is based on the total amount of received citations from within the data set, and every
timeslice is labeled with the total citation frequency and in-degree strength (i.e., the number of citing timeslices within the data set).

As a complement to timeline visualization II the top five cited articles from all timeslices with \( \geq 100 \) received citations was identified and are shown in Table 3, 4, and 5.

5. Results and discussion

In this section the results are presented and discussed: an overview – as well as interpretational aspects – of the three visualizations are presented in the sections 5.1 Timeline visualization I: publications and research topics, 5.1.1 Keyword network: identifying sub-themes, and 5.2 Timeline visualization II: information flow, followed by a more detailed description of each individual research front in section 5.3 The research fronts of motivation research within SEP between 1985 and 2009, on the basis of the conducted analyses and the three visualizations.

Figure 6 show publication frequencies in motivation research within SEP between 1985 and 2009 based on the 739 article set. According to the diagram the activity and growth of motivation research within SEP seem quite intense between 2000 and 2009, and especially between 2005 and 2009. However, some caution is needed when interpreting the diagram. It is difficult to determine if, or to which degree, the intense growth between 2000 and 2009 – as reflected in the diagram – is a consequence of a real increase in publication output in the specialty, or if it is a consequence of indexing effects in WoS.
Figure 6. Number of publications within motivation research in SEP between 1985 and 2009 based on the 739 article set including outliers.

5.1 Timeline visualization I: publications and research topics

Figure 7 shows a timeline consisting of 19 research fronts within motivation research in SEP, and their development between 1985-2009. In the coordinate system every research front is represented by a number and a classification name (to the right) assigned by a subject expert. Each research front timeslice – 1985-1994; 1995-1999; 2000-2004; and 2005-2009 – is represented by a node and the node size corresponds to the number of publications, also indicated by a number. Timeslices with less than five publications was not considered representative of an active research front timeslice. These small timeslices are represented as empty circles denoted by <5. The placement of the research fronts was based on correlations between PCs so that similar research fronts could be placed near each other. The color of a node corresponds to which PC the research front node belongs. The PC number can be seen to the left in the visualization.

The PCA produced three PCs. The research conducted within the research fronts included in PC 1 (green nodes), seem to revolve around achievement goal theory and achievement goals oriented themes. PC 2 (red nodes), seems very coherent, and contains research fronts revolving around self-determination theory. In PC 3 (blue nodes) – the least coherent of the PCs (with respect to content) – research fronts with other theoretical foundations (mostly active in timeslice 1985-1994) than achievement goals theory and self-determination theory
was gathered (e.g., Harter's competence motivation theory (much used in research front 10. Perceived competence and motivation among children and youth); Self-efficacy; Attributions).

Timeslice 1985-1994 seem to contain five research fronts with different topics and theoretical foundations. Research front 15. Intrinsic motivation, is located within the Self-determination theory oriented PC 2, and Research front 2. Task-ego achievement goals 1, is located within the achievement goals oriented PC 1. In PC 3, there was three active research fronts: 10. Perceived competence and motivation among children and youth; 6. Goal-setting and self-efficacy; and 19. Attributions. Given the development of motivation research within SEP as represented in Figure 7 the self-determination oriented research front 15. Intrinsic motivation and the achievement goals oriented research front 2. Task-ego achievement goals 1, can be seen as representing the early developments of two research orientations that would become very prominent areas of research in the latter timeslices. It is unclear if the three active research fronts in PC 3 are at their peak during this period or if they peaked during some previous period and have been in decline for some time. Either way, given that the time period between 1985 and 1994 consist of five research fronts quite similar in size with different research topics and theoretical foundations, no “dominating” research orientation or sub-area could be recognized between 1985 and 1994. The, identified research fronts was in line with earlier reviews (e.g., in Roberts (1992, p. 8-15) the theoretical frameworks of attribution theory, theory of self-efficacy, and motivation theories revolving around perceived competence and achievement goals approaches, was suggested as the dominating theories and approaches at the time).

The timeslices of 1995-1999 and 2000-2004 seem to be dominated by achievement goals oriented research fronts as can be seen in PC 1 (e.g., 2. Task-ego achievement goals 1; 14. Task-ego achievement goals 2; 16. Motivational climate). From a “bird’s eye view” these results seem to be in accordance with earlier review literature (see section 2.1). In a comparison between the timeslices of 1995-1999 and 2000-2004 in PC 1, it is interesting to see how the large and more general research fronts in the former timeslices (e.g., 2. Task-ego achievement goals; 14. Task-ego achievement goals 2; 16. Motivational climate), seem to develop (see Figure 9 for information flow) into more differentiated and coherent research fronts in the latter timeslices (e.g., 11. Motivational climate, achievement goals, and psychosocial outcomes; 8. Influence of significant others; 12. Motivational climate, achievement goals, and moral behaviors). The research fronts in PC 3 that were active in timeslice 1985-1994 were in decline and became inactive during the timeslices of 1995-1999.

In the time period of 2005-2009, a rather drastic increase of self-determination oriented research can be observed (e.g., 13. Self-determination theory 3; 4. Self-determination theory 4; 9. Self-determination theory and exercise behaviors). In PC 1 many research fronts with initial activities in the previous time periods continue to grow (e.g., 8. Influence of significance others; 12. Motivational climate, achievement goals, and moral behaviors). Some research fronts in PC 1 show quite an intense growth: 5. Approach-avoidance achievement goals; 11. Motivational climate, achievement goals, and psychosocial outcomes. During the time period of 2005-2009, self-determination theory and achievement goals are the dominating lines of research, which seem to correspond with the review literature (see section 2.1). They seem to be very similar in size (i.e., publication frequencies), but while the achievement goals oriented research fronts show many differentiated and well distinguished research fronts in terms of themes and topics, the self-determination theory oriented research fronts seem much less differentiated.

It is difficult to determine if these clusters (i.e., the non-differentiated self-determination, as well as, the achievement goals oriented research fronts) are based on real, but unidentified differences, if the division into separate clusters is artificial, or has other causes than content related ones such as social factors tied to the citation process. Potentially, many different reasons, that are probably intertwined, could be addressed to explain this phenomenon. I suggest four potential causes here:

1. According to Zitt, Lelu, and Bassecoulard (2011, p. 21), factors such as national contexts and tight networks of collaborating researchers can produce very specific, or local, repertoires of references (i.e., intellectual bases). This phenomenon could result in situations where two research communities or collaborative groups are working on the same research problems, share vocabulary, but not intellectual base. In such cases, a cluster analysis based on BC would produce two clusters rather than one, resulting in a fragmentation of the active research front.

2. It has been suggested that bibliographic coupling tend to be sensitive to the length of the timespan of the analysis. According to Glänzel and Czerwon, (1996, p. 219-220): “long-term observations (5-10 years or more) bibliographic coupling does not reflect
the relationship between documents in an adequate manner. In particular, the reference structure of related papers changes because of the incorporation of more topical, e.g., citing papers into the reference lists thus weakening the strength of bibliographic links”. This suggestion seems to be in conflict with the assumptions made by Morris, Boyack (2005), and Morris et al. (2003), and their timeline visualization method (used in this study), where timespans of 60 years was used in cluster analyses with BC with valid results. I find it plausible that the length of the timespan can produce fragmentation effects in cluster analyses with BC, however, to which degree such fragmentation effects was responsible for the phenomenon of non-differentiated research fronts in this study would require a more in depth examination of the reference structure of these particular research fronts. Some methodologically oriented suggestions to compensate for the potential fragmentation due to BC is suggested in the section, 6. Conclusions.

3. According to a subject expert from the field of SEP the non-differentiated self-determination oriented research fronts could have to do with the fact that self-determination theory is a universal theory, and could potentially be used very broadly in SEP, among a wide variety of research problems, sub-topics and themes. This hypothesis could also explain the differences between the achievement goals and self-determination oriented research fronts in terms of specificity, it might just be the case that self-determination theory are used in a broader sense than achievement goals theory in SEP.

4. Another factor – with respect to the differences in research front differentiation between research themes (e.g., self- determination/achievement goals) – could of course be the relative newness of many of the self-determination oriented research fronts compared to the achievement goals oriented ones.

5.1.1 Keyword network: identifying sub-themes
The keyword network (Figure 8) consists of nine separate components, two larger components and seven small. The seven small components consist of a single research front and its corresponding top five keywords. Even though the purpose of this network was to provide a more differentiated view of the research fronts and aid the interpretation by extracting underlying vocabularies and themes specific to each research front, it is interesting to notice that the structure of the two large components clearly reflects the cognitive structure
shown in the timeline visualization. In the two larger components research front nodes are connected through keywords, the cognitive relationship between research fronts in terms of shared vocabularies is strengthened by the number of connections and by the strength of the connections (represented by the width of the connecting lines).

The large purple component to the right in Figure 8 containing six research fronts correspond to PC 1, research fronts with achievement goals orientations, and the light green component to the right containing six research fronts correspond to PC 2, with self-determination theory orientations. The four research fronts found within PC 3 are located on the upper right side of the map, and research fronts belonging to either achievement goals or self-determination but had very specific vocabularies and therefore lacked connections was placed near respective components.

Here the non-differentiated research front 17. Task-ego achievement goals 3 (upper left corner of map), is taken as an example of an identified underlying theme through the inspection of the keyword network. By inspecting this network consisting of 1 research front node, and five keywords of which two seemed interesting, “imagery”, and “sport imagery questionnaire”. These keywords was of interest because the term imagery occurred twice, but not among the top five in any other research front, indicating that imagery is part of a vocabulary specific to this research front. By investing the abstracts and titles of the articles belonging to this research front, five imagery oriented articles was found, and four of them was published during the time period of 2000-2004, which contained a total of 10 articles, indicating that imagery was an active sub-theme within this research front during this period of time.

5.2 Timeline visualization II: Direct citation network
Timeline visualization II, as can be seen in Figure 9, is based on the same coordinate system as timeline visualization I in figure 7. In direct citation networks “it is possible to trace information flow from the early research fronts to the latest, more specialized research fronts” (Morris et al., 2003, p. 417). In Figure 9 the flow of information is based on DCs between documents aggregated to the level of research front timeslices (N = 62).

The DC network (see Figure 9) gives indications about:

1. Significant paths of information flow between different research fronts and timeslices within the network.
2. Highly influential research fronts and timeslices (e.g., Timeslice 1985-1994 in research front 2, Task-ego achievement goals 1; timeslice 1995-1999 in research front 14, Task-ego achievement goals 2; timeslice 1995-1999 in research front 1, Self-determination theory 1).

3. Potential parent-child relations between the cited and citing research front (e.g., 2, Task-ego achievement goals 1 and 16, Motivational climate).

4. Research fronts that have developed an internal base literature specific to its own research theme (e.g., 9, Self-determination theory 2; 12, Motivational climate, achievement goals, and moral behaviors; 26, Motivational climate). As well as research fronts that have a large part of their intellectual base outside the specialty (e.g., 5, Approach-avoidance achievement goals; 8, Influence of significant others; 3, Participation motivation in sport and physical activity).

As can be seen in Figure 9 there are little cross-citations between the three PCs, which indicates that the research fronts in PC 1, 2, and 3 are relatively isolated in terms of influencing each other. However, four research fronts show patterns of cross-citations: Self-determination theory 2 and Self-determination theory 4 in PC 2 cites Motivation towards physical education and physical activity in PC 1, Motivation towards physical education and physical activity in PC 1 cites research front Self-determination theory 1 in PC 2, and research front Influence of significant others in PC 1 cites research front Perceived competence and motivation among children and youth in PC 3.

The top five most influential research fronts within the specialty motivation research within SEP were: (1) Task-ego achievement goals 1; (2) Task-ego achievement goals 2; (3) Self-determination theory 1; (4) Motivational climate; (5) Perceived competence and motivation among children and youth.
Figure 7. Show 19 research fronts with classifications, when they emerge and disappear, and their size in terms of publication frequencies. The number within the parenthesis after each research front name denotes publication frequency.
Figure 8. Keyword network based on the top 5 TF-IDF RAKE keywords. Lines with TF-IDF scores ≥ 2 are removed, unless they connect a research front node and a top 5 keyword, these keyword are represented with dotted lines. Widths of lines indicate the importance of a keyword to a research front. The size of research front nodes indicate total number of publications, keyword size indicate in-degree (i.e., total number of connections).
Figure 9. Display the flow of information within the area of motivation research in SEP in terms of DC. Based on ≥ 15 DC.
Table 3. Top five cited articles from research fronts in timeslice 1985-1994 with \( \geq 100 \) received citations.

<table>
<thead>
<tr>
<th>Citations</th>
<th>Research front 15: Intrinsic motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>88</td>
<td>McAuley, et al. (1989a). Psychometric properties of the intrinsic motivation inventory in a competitive sport setting - a confirmatory factor-analysis</td>
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<tr>
<td>17</td>
<td>McAuley, et al. (1989b). The effects of subjective and objective competitive outcomes on intrinsic motivation</td>
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<tr>
<td>6</td>
<td>Vallerand, et al. (1988). On the relative effects of positive and negative verbal feedback on males and females intrinsic motivation</td>
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<tr>
<td>2</td>
<td>Thill, et al. (1990). Autonomy or control in a sport context - the validity of the theory of cognitive-evaluation</td>
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<th>Research front 2: Task-ego achievement goals</th>
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<th>Research front 10: Perceived competence and motivation among children and youth</th>
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Table 4. Top five cited articles from research fronts in timeslice 1995-1999 with \( \geq 100 \) received citations.

<table>
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<tr>
<th>Citations</th>
<th>Research front 1: Self-determination theory</th>
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<td>107</td>
<td>Pelletier, et al. (1995). Toward a new measure of intrinsic motivation, extrinsic motivation, and amotivation in sports - the sport motivation scale (sms)</td>
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<tr>
<td>42</td>
<td>Briere, et al. (1995). Development and validation of the EMS for the measurement of intrinsic motivation, extrinsic motivation and non-motivation in sports - Echelle de Motivation dans les Sports</td>
</tr>
</tbody>
</table>
Ryan, et al. (1997). Intrinsic motivation and exercise adherence


Research front 14: Task-ego achievement goals 2


Duda, et al. (1996). From theory to practice: The integration of goal perspective theory and life development approaches within an injury-specific goal-setting program

Dunn, et al. (1999). Goal orientations, perceptions of aggression, and sportspersonship in elite male youth ice hockey players

Newton, et al. (1999). The interaction of motivational climate, dispositional goal orientations and perceived ability in predicting indices of motivation

Goudas, et al. (1995). It ain't what you do, its the way that you do it - teaching style affects childrens motivation in track and field lessons

Research front 2: Task-ego achievement goals 1


Roberts, et al. (1996). Effect of goal orientation on achievement beliefs, cognition and strategies in team sport


Research front 16: Motivational climate


Papaioannou, et al. (1995). Differential perceptual and motivational patterns when different goals are adopted

Solmon, et al. (1996). Impact of motivational climate on students' behaviors and perceptions in a physical education setting

Papaioannou, et al. (1999). The effect of task structure, perceived motivational climate and goal orientations on students' task involvement and anxiety

Table 5. Top five cited articles from research fronts in timeslice 1995-1999 with ≥ 100 received citations.

<table>
<thead>
<tr>
<th>Citations</th>
<th>Research front 9: Self-determination theory and exercise behaviors</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>Markland, et al. (2004). A modification to the behavioral regulation in exercise questionnaire to include an assessment of amotivation</td>
</tr>
<tr>
<td>22</td>
<td>Wilson, et al. (2003). The relationship between psychological needs, self-determined motivation, exercise attitudes, and physical fitness</td>
</tr>
<tr>
<td>19</td>
<td>Wilson, et al. (2004). The relationship between perceived autonomy support, exercise regulations and behavioral intentions in women</td>
</tr>
</tbody>
</table>
Vansteenkiste, et al. (2004). How to become a persevering exerciser? Providing a clear, future intrinsic goal in an autonomy-supportive way


### Research front 7: Motivation towards physical education and physical activity

| 17 | Vansteenkiste, et al. (2004). How to become a persevering exerciser? Providing a clear, future intrinsic goal in an autonomy-supportive way |

### Research front 12: Motivational climate, achievement goals, and moral behaviors

| 19 | Lemyre, et al. (2002). Achievement goal orientations, perceived ability, and sportspersonship in youth soccer |
| 13 | Miller, et al. (2004). Motivational climate, beliefs about the bases of success, and sportspersonship behaviors of professional basketball athletes |
| 13 | Ommundsen, et al. (2003). Perceived motivational climate in male youth soccer: relations to social-moral functioning, sportspersonship and team norm perceptions |
| 13 | Kavussanu, et al. (2002). Contextual influences on moral functioning of college basketball players |

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### 5.3 The research fronts of motivation research within sport and exercise psychology between 1985 and 2009

This section consists of a presentation of the 19 identified research fronts. The research fronts are presented from top to bottom after PC belonging in the timeline, and further, within each timeline, from oldest to newest. The presentation displays active period(s) of each research front, possible sub-themes or other interesting results identified with the keyword network, and position in the direct citation network (i.e., the degree to which a research front timeslice have been influencing or have been influenced by others). The number within the parenthesis after each research front name denotes publication frequency.

PC 2:

- **15. Intrinsic motivation (#15):** was active in timeslice 1985-1994 \((n = 7)\), but had at least one publication in all timeslices (see Figure 7). An early research front within the framework of self-determination theory. With 124 citations from within the network it can be considered quite influential. As can be seen in Table 3 the article Mcauley, et al. (1989a). *Psychometric properties of the intrinsic motivation inventory in a*
competitive sport setting - a confirmatory factor-analysis, has received 88 of those citations, and can be considered a base document. High in-degree (n = 34), and low degree of strong connections, indicates that Mcauley, et al. (1989a), was used in a wide variety of research fronts.

- **1. Self-determination 1 (#22):** had at least one publication in every timeslice and show activity in timeslice 1995-1999 and 2005-2009 (see Figure 7). Timeslice 1995-1999 has been cited ≥15 times by all research fronts in PC 2 and also by research front 7. Motivation towards physical education and physical education in PC 1. With 322 citations it is the most highly cited research front in PC 2. As can be seen in Table 4 one article has received almost a third of the citations directed to 1. Self-determination 1: Pelletier, et al. (1995). Toward a new measure of intrinsic motivation, extrinsic motivation, and amotivation in sports - the sport motivation scale (sms), which can be considered a base document within self-determination theory oriented motivation research within SEP.

- **9. Self-determination theory and exercise behaviors (#54):** became active in timeslice 2000-2004 (n = 11), and show a drastic growth in timeslice 2005-2009 (n = 42) (see Figure 7). Except for research front 15. Intrinsic motivation, it is the only self-determination oriented research front in PC 2 that could be differentiated in terms of classification. As can be seen in Figure 9 research front 1. Self-determination theory 1 quite extensively cited, but more interestingly, timeslice 2005-2009 cites timeslice 2000-2004 to a large extent, which indicates that research front 9. Self-determination theory and exercise behaviors have a quite developed intellectual base of specific publications produced within the research front itself (see Table 5 for top five cited articles).

- **18. Self-determination theory 4 (#23):** was active during timeslices 2000-2004 (n = 6) and timeslice 2005-2009 (n = 17) (see Figure 7). As can be seen in Figure 9 it cited timeslice 1995-1999 in research front 1. Self-determination 1 and timeslice 2000-2004 in research front 7. Motivation towards physical education and physical activity in PC 1. According to Figure 8 it has a very coherent self-determination oriented vocabulary. In terms of sub-themes “physical activity” was investigated due to the influences from research front 7. Motivation towards physical education and physical activity and the keyword “physical activity enjoyment scale”: in timeslice 2000-2004 three (i.e., 50%) physical activity oriented articles was found, and six (i.e., 28%) in timeslice 2005-
2009, which indicates that physical activity could be considered a sub-theme during these time periods.

- **13. Self-determination theory 3 (#32):** became active in timeslice 2005-2009 \((n = 29)\) (see Figure 7). And cited 1. Self-determination 1 to a large extent. In terms of underlying themes “intrinsic” and “extrinsic motivation” was investigated (see Figure 8), and 15 (i.e., 52\%) of the articles had intrinsic/extrinsic orientations. Further the “sport motivation scale”, developed by Pelletier et al. (1995), was much used in these intrinsic/extrinsic oriented articles.

- **4. Self-determination theory 2 (#43):** became active in timeslice 2005-2009 \((n = 41)\) (see Figure 7). As can be seen in Figure 9 it cited a wide variety of research fronts. It was the only self-determination oriented research front that cited 15. Intrinsic motivation, and research front 7. Motivation towards physical education and physical activity \(\geq 15\). In terms of underlying themes two synonymously intertwined keywords was investigated: “coach autonomy support” and “autonomy supportive coaching” (see Figure 8). These keywords occurred in 7 articles (i.e., 17\%) between 2007 and 2009 and they did not occur in any other research front. Thus, “coach autonomy support” could be understood as a sub-theme in research front 4. Self-determination theory 2, as well as within self-determination oriented SEP research as such.

PC 1:

- **2. Task-ego achievement goals 1 (#44):** the earliest timeslice in PC 1, it was active during 1985-1994 \((n = 12)\), 1995-1999 \((n = 14)\), and 2000-2004 \((n = 14)\) (see Figure 7). During these periods this research front underwent a successive decline. It contains two highly cited timeslices. As can be seen in Figure 9, timeslice 1985-1994 is the most cited timeslice in the whole network. It was cited by most of the research fronts in PC 1, indicating that it contains important base documents for achievement goals oriented motivation research in SEP (see Table 3). In particular it seems to have influenced the research fronts 14. Task-ego achievement goals 2; 16. Motivational climate; and 11. Motivational climate, achievement goals, and psychosocial outcomes.

- **14. Task-ego achievement goals 2 (#65):** show activities in 1995-1999 (largest timelsice in the network \(n = 33\)), 2000-2004 \((n = 19)\), and 2005-2009 \((n = 12)\) (see Figure 7). It directed a large amount of citations to research front 2. Task-ego achievement goals 1 and was much cited by almost all other research fronts within PC
1, indicating a broad influence within achievement goals oriented research in motivation research in SEP (see Table 3 for top 5 cited articles).

- **11. Motivational climate, achievement goals, and psychosocial outcomes (#35):** became active, but was quite marginal, during timeslices 1995-1999 \((n = 6)\) and 2000-2004 \((n = 6)\), and experienced a significant growth in timeslice 2005-2009 \((n = 23)\) (see Figure 7). This research front cites 2. Task-ego achievement goals 1; 14. Task-ego achievement goals 2; and 16. Motivational climate. Figure 8 displays three keywords containing anxiety (somatic anxiety, cognitive anxiety, performance anxiety), indicating that anxiety may have been a potential sub-theme. Anxiety occurs in four (i.e., 66%) of the articles in timeslice 1995-1999, and in 10 articles (i.e., 43%) in timeslice 2005-2009. Somatic and cognitive anxiety dominates timeslice 1995-1999, and timeslice 2005-2009 is dominated by performance anxiety.

- **16. Motivational climate (#62):** became active in timeslice 1995-1999 \((n = 17)\) and increased during timeslice 2000-2004 \((n = 20)\) and 2005-2009 \((n = 25)\) (see Figure 7). Cited timeslice 1985-1994 in research front 2. Task-ego achievement goals 1 and seem to have developed a solid base literature in timeslice 1995-1999 (see Figure 9), where an educational context seem to be central in the top 5 cited articles (see Table 4).

- **7. Motivation towards physical education and physical activity (#33):** became active in timeslice 2000-2004 \((n = 16)\) and remains active in 2005-2009 \((n = 16)\) (see Figure 7). The citation patterns show that it cited research fronts in both PC 1 (14. Task-ego achievement goals) and PC 2 (1. Self-determination theory 1) (see Figure 9 and Table 5). Its relations with both self-determination and achievement goals orientations is also reflected in Figure 8, where this research front, with respect to vocabulary, is placed within the self-determination theory component, and not the achievement goals component.

- **8. Influence of significant others (#21):** became active in timeslice 2000-2004 \((n = 6)\) and more than doubles in size in timeslice 2005-2009 \((n = 14)\) (see Figure 7). Given the threshold of \(\geq 15\) citations, it is also the only research front from within PC 1 and 2 that cites a research front in PC 3: 10. Perceived competence and motivation among children and youth (see Figure 9). As can be seen in Figure 8 this research front has developed a very specific vocabulary.

- **12. Motivational climate, achievement goals, and moral behaviors (#33):** became active in timeslice 2000-2004 \((n = 12)\) and 2005-2009 \((n = 19)\) (see Figure 7). As can
be seen in Figure 9, timeslice 2000-2004 was much cited by timeslice 2005-2009, indicating that this research front has developed an intellectual base specific to its own context (see Table 5). This is also reflected in Figure 8, where a quite specific and coherent vocabulary can be observed.

- **17. Task-ego achievement goals 3 (#18):** became active in timeslice 2000-2004 \((n = 10)\) and decreased in size in timeslice 2004-2009 \((n = 6)\) (see Figure 7). With respect to Figure 8 the term imagery was investigated. Five imagery oriented articles was found in the research front, and four (i.e., 40%) of them was published during the time period of 2000-2004, indicating that imagery was an active sub-theme within this research front during this period of time.

- **5. Approach-avoidance achievement goals (#30):** became active in timeslice 2005-2009 \((n = 25)\). Given the timeframe of this study, this research front is the most recent within PC 1 (see Figure 7). It seem to have developed a foundation of base literature in timeslice 2000-2004. Another influencing research front was 7. Motivation towards physical education and physical activity (see Figure 9). As indicated in Figure 8, this research front seems to have a well distinguished and coherent vocabulary.

PC 3:

- **10. Perceived competence and motivation among children and youth (#27):** was active in timeslice 1985-1994 \((n = 16)\), declined in timeslice 1995-1999 \((n = 7)\), and became inactive in timeslice 2000-2004. When inspecting the articles Harter’s competence motivation theory was a highly influencing theoretical framework. As seen in Table 3, Duda, et al. (1989). Toward a developmental theory of childrens motivation in sport, has received 94 citations (52%) can be considered a base document. This research front has been quite influential in the research front 8. Influence of significant others.


- **19. Attributions (#15):** was active in timeslice 1985-1994 \((n = 12)\). Revolves around the theoretical framework of attributions. As can be seen in Figure 9 this research front is quite isolated in terms influencing other research fronts within the network.
• **3. Participation motivation in sport and physical activity (#16):** became active in timeslice 2005-2009 \((n = 6)\). As can be seen in Figure 9 this research front is quite isolated in terms influencing other research fronts within the network.

### 6. Conclusions

The purpose of this study was to map the intellectual structure of the specialty of motivation research in SEP, and to show how the intellectual structure of this research specialty had changed over time. Two aspects of the intellectual structure were investigated: (1) the growth and decline of research fronts within motivation research in SEP, and (2) the flow of information between these research fronts. A secondary explorative purpose was to examine possibilities and limitations concerning a longitudinal analysis of motivation research in SEP.

This was achieved by (1) delineating motivation research in SEP with a multi-database approach based on controlled vocabulary, where articles from PSYCHinfo and SPORTdiscus was identified and retrieved in WoS, the article set was further expanded by citations-based extension, and (2) performing a cluster analysis on the retrieved articles based on bibliographic coupling strength, and further, exploring the clusters plotted as research fronts along timelines in a coordinate system.

Some limitations, and potential improvements, were found:

1. It was concluded that the data collection and field delineation approach with multiple databases was successful in addressing the problems of low recall concerning the early time periods with the lexical query approach, and in comparison with the earlier review literature the early timeslice of 1985-1994 seemed representative, however, some further procedures could be tested to improve recall during this period. Especially with respect to the indexing delays of the core journals in WoS it would seem appropriate to try to increase recall in future studies. The time period of 1985-2009 was chosen on the basis of retrieved articles, with an improved recall the longitudinal perspective could possibly be stretched further back. In the citation based extension phase I used direct citations to identify potentially similar articles by which the core set could be expanded. In order to increase the recall of articles potentially similar to the core set of articles, the rationale of bibliographic coupling or lexical coupling might be a more suitable choice. However, there is – to my knowledge – a limitation to this approach. While citation based extension based on direct citations are supported by WoS through the *Create citation report* function, the coupling strategies
would require full access to the WoS database (Mogoutov & Kahane, 2007, p. 895), and such an access was not available during this study. Two more realistic suggestions would be to reiterate the citation based extension phase to increase recall, or try to use BC or lexical coupling on a limited subset of articles downloaded from WoS, in order to further expand the core set (e.g., the core journals could be used to delimit a subset of articles, and by applying BC or lexical coupling, the core set could potentially be expanded, which would increase recall in the subsequent phase of citation based extension)

2. The phenomena of non-differentiated research fronts, or cluster fragmentation, could potentially be addressed with so called hybrid clustering methods, where traditional bibliometric measures such as BC are combined with lexical approaches in the mapping of science. It has been shown that the coupling-lexical hybrid approaches tend to complement each other, adjust for weaknesses, and outperform “citation-only” and “text-only” approaches with respect to document-document similarity (Ahlgren & Colliander, 2009; Frizo Janssens, Glänzel, & De Moor, 2008). The use of a hybrid approach would also deem the threshold used in the cluster analysis to exclude outliers and enhance the cluster quality unnecessary. The excluded articles due to this threshold were to a large extent published during the timeslice of 1985-1994. Thus, a hybrid approach would potentially enhance the representativity of the study as such.

Even though some limitations of the study were identified, the results provided a comprehensive overview of the intellectual structure of the research fronts of motivation research in SEP between 1985 and 2009. Some main findings was: (A) timeslice 1985-1994 consisted of a dispersed collection of research fronts with similar sizes. No dominating research theme or theoretical framework could be discerned in this period; (B) the timeslices of 1995-1999 and 2000-2004 was dominated by achievement goals oriented research; (C) during timeslice 2004-2009 self-determination theory oriented research underwent a drastic growth. This timeslice was dominated by achievement goals oriented research and self-determination theory oriented research; (D) overall, there seem to be little cross-citations between the three PCs, they seem to be quite isolated in terms of influencing each other. However, four research fronts show patterns of cross-citations: Self-determination theory 2 and Self-determination theory 4 in PC 2 cites Motivation towards physical education and physical activity in PC 1, Motivation towards physical education and physical activity in PC 1 cites research front Self-determination theory 1 in PC 2, and research front Influence of
significant others in PC 1 cites research front *Percieved competence and motivation among children and youth* in PC 3; (E) citation patterns indicated that three research fronts had developed “research front specific” intellectual bases: *Self-determination theory and exercise behaviors; Motivational climate, achievement goals, and moral behaviors; Motivational climate*; (F) the top five most influential research fronts within the specialty motivation research within SEP – in terms of received direct citations – was: (1) *Task-ego achievement goals 1*; (2) *Task-ego achievement goals 2*; (3) *Self-determination theory 1*; (4) *Motivational climate*; (5) *Percieved competence and motivation among children and youth*.

Even though the direct citation network show how the research fronts within the specialty influence each other, quite a few research fronts seem to have a large part of their intellectual bases outside the specialty. In a future study it would be interesting to further explore the intellectual base of the specialty of motivation research in SEP to gain a broader picture of the influential literature. As noted by Zhou and Strotman (2008, p. 2084-2085), analyses of the intellectual base of a field and its research fronts can complement each other and provide a more thorough view of the intellectual structure of a field, especially when it comes to the study of changes over time.

Due to the increase of interdisciplinary research in science (Wagner et al., 2011, p. 14), methods and tools for the delineation of complex scientific fields and sub-fields have gained quite some attention in recent years (e.g., Laurens et al., 2009; Maghrebi, Abbasi, Amiri, Monsefi, & Harati, 2011; Mogoutov & Kahane, 2007; A Strotmann & DZ Zhao, 2010). Two findings in this study that could be further explored in future research within the context of field delineation could be: (1) a further exploration of the use of complex queries to retrieve articles in WoS with respect to the multi-database approach based on controlled vocabulary and (2) a further examination of the use of weighted direct citations when performing citation-based extension in the delineation of complex fields.
7. Reference list


Boyack, K. W., & Klavans, R. (2010). Co-Citation Analysis, Bibliographic Coupling, and Direct Citation: Which Citation Approach Represents the Research Front Most Accurately? *Journal of the American Society for Information Science and Technology, 61*(12), 2389-2404. doi: 10.1002/asi.21419


