Working Paper

DOES COGNITIVE DISTANCE AFFECT PRODUCT DEVELOPMENT FOR DISTANT TARGET GROUPS?

Evidence from the literature using co-citation methodology

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June 2015
Working Paper Nr. 89

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Abstract

The level of cognitive distance determines how detailed objects, persons or events are mentally construed. The higher the level of cognitive distance between two individuals, the lower the level of detail in mental representation of each other. In product development, a detailed conception of the target group is essential for future product success. Product developers need to establish an accurate mental representation of the user and internalize customer preferences to ensure product usability and/or delivery of adequate services in new product development projects (NPD). Depending on the target group in focus, potential users can be distant in various dimensions. Silver Agers (65+ years of age) can be a distant target group for product developers in terms of age and personal contacts as most developers are too young to fall in the category of Silver Agers. Thus, they have likely taken different life experience paths compared to people of their own age cohort. Management and psychological science refers to this phenomenon as cognitive or psychological distance. Especially for distant target groups (e.g. elderly people or children), cognitive distance between product developers and users might have an impact on the creation of new products/services. Literature in this field, especially within an innovation context, is very scarce. Therefore, this paper analyzes existing research streams and thought schools of cognitive distance literature and their applicability in an innovation context to study implications for NPD. We use co-citation analysis to identify and visualize the different research areas dealing with cognitive distance, and to detect conceptual subdomains applicable for individual relationships between product developers and (distant) target groups. We find eight relevant clusters dealing with cognitive distance in psychology and innovation management-related research papers. Construal level theory stands out as the predominant theoretical foundation of cognitive distance in psychological research. It states that distant persons, objects or events in terms of space, time, social or probability are mentally construed in a more abstract way as opposed to nearer/closer/more likely persons, objects or events. Applied to product developers' mental representation of the actual users, this infers that users of distant target groups are likely to be represented more abstractly compared to proximal target groups, e.g. target groups of similar age. This lesser differentiated view on users could lead to non-optimal solutions in NPD. We thus propose that cognitive distance can have an impact on product development. We discover a knowledge gap on the individual level for innovation management studies, i.e. linking cognitive distance to product development success. We analyze findings from psychological research on individual cognitive distances and find that besides temporal distance, the social dimension of cognitive distance appears to be most relevant for empirical tests in innovation management. To empirically explore and test dimensions of social distance, we argue to utilize established network-theoretic measures, like social capital as a proxy for social distance between product developers and distant target groups. We close with practical suggestions to mitigate adverse effects of cognitive distance for product developers.

Keywords: Cognitive distance, psychological distance, Silver Market, distant target group, innovation management

Introduction – Customer representation in new product development

Meeting customer needs, wants and preferences is one of the most important factors for successful product innovation (Cooper & Kleinschmidt, 1987). Thus, firms are urged to integrate the "voice-of-the customer" into new product development (Griffin & Hauser, 1993), i.e. translate specific customer needs in product specifications. In doing so, product developers internalize customer needs and establish their own mental representation of the customer. This representation also depends on existing

customer knowledge, individual life experience paths and cognition. In conjunction with (technical) solution knowledge, product developers create products/services to serve these needs. Each developer's representation is an interpretation of the actual needs, the resulting products/services are materializations based on these individual customer representations. Therefore, the actual materialization in the design can deviate from actual needs. Precisely, developers embed a specific usability pattern, i.e. how they envision the customer to use the product, into the design (so-called 'script') (Akrich, 1992). Thus, the correctness of customer representations have a significant impact on customer-centric new product designs leading to product innovation success or failure.

Cognitive distance

The terms psychological and cognitive distance are used interchangeably in the literature, so do we for the course of this paper.

In the field of cognitive psychology, cognitive distance is defined as "the extent of divergence from direct experience of me, here and now along the dimensions of time, space, social perspective, or hypotheticality [probability]" (Liberman & Trope, 2014, p. 365). All psychological distances are egocentric, which means they are anchored on the direct experience of the now and here (zero distance point). To move beyond this zero distance point to the past or future, geographically distant places, experiences of other people, and hypothetical alternatives to reality involves mental construal (Liberman, et al., 2007). The estimation of distance is perceived, subjective rather than being decided by objectively measured units (Ibid.). In an innovation context, the notion of cognitive distance is established by Nooteboom in his earlier work regarding the cognitive theory of the firm according to the constructivist view of knowledge (Nooteboom, 1992). From this view, people's perceptions and evaluations of the world are established based

on interactions with their environment. People, therefore, have different views of the world as a result of different cognitions that developed in different conditions along their life paths (Berger & Luckmann, 1966).

Although being rooted on the individual level, papers on a group/team level as well as between organizations have been published. On the individual level, extended from the field of cognition psychology, scholars demonstrate that cognitive distance estimates do not correlate to objective distance measure. Hence, cognitive distance is a mental approximation of actual distance based on "an individual's social, cultural and general life experiences" (Harrison-Hill, 2001, p. 3). On a team/work group level, papers were published on geographically dispersed or virtual teams. Researchers acknowledge cognitive or subjective distance compromising geographical and configurational dispersion and national diversity among team members (Siebdrat, et al., 2014). Wilson et. al. (2008, p. 983) propose that perceived proximity, "a dyadic and asymmetric construct which defines one person's perception of how close or how far another person is", has significant impact on dispersed team processes.

On an organizational level, cognitive distance has been studied due to the fast growth in inter-organizational alliances. Here, the performance of collaborations between organizations is affected by cognitive distance, measured by the difference in their knowledge base (Nooteboom, 2000a). Nooteboom has proven that cognitive distance has an inverted U-shaped effect on innovation performance of a firm (2007). Hence, innovation performance of cooperating firms is optimal at a certain distance. Too little cognitive distance leads to lower innovation performance due to redundant knowledge bases. Too high distance leads to lower innovation performance due to a lack of mutual understanding.

Silver Agers as distant target group

We will refer to Silver Agers as an example of a distant target group for the course of this paper. Silver Agers (60+ years of age) present a distant target group for many corporate product developers as regular retirement age is at around sixty years in many countries. Hence, most corporate developers cannot be considered Silver Agers themselves. Furthermore, it is a highly relevant emerging target group for consumer goods/services companies as the global population of elderly persons (aged 60 years and above) is projected to grow from 841 million in 2013 to more than 2 billion in 2050 (United Nations, 2013). The Silver Market is made up of a heterogeneous population covering a diverse range of customers with different values, attitudes, needs and wants, since individual differences tend to increase over the course of life (Kohlbacher & Herstatt, 2008), which especially requires developers to build upon a detailed and concrete user representation in the design of new products.

For product developers, acquired target group need-knowledge contributes to individual customer representations. Therefore, knowledge of older people is a prerequisite in the design and development of products for the Silver Market. Despite considerations given to the representation of older people as a heterogeneous group, stereotypical representations such as dependence, illness, resistance to change and technological illiteracy still exist (Minichiello, et al., 2000). This may result in ageism, which is discrimination against individuals or groups because of their age, oversimplifying the characteristics of Silver Agers. Therefore, ageism can affect customer representations of Silver Agers in NPD processes. To avoid ageism, more accurate mental representations of older people are crucial, especially when 20-40 year olds develop for Silver Agers aged 60-80 (Mynatt & Rogers, 2001) and age-differences can render product developers' assumptions of shared experiences

with the Silver Ager target group misplaced (Hyysalo, 2009).

Forming customer representations to match customer needs is generally essential in NPD processes. Especially when developing for target groups, like Silver Agers, other factors, like age-differences, technology generations or different life experience paths can further influence developers' adequate customer representations. Thus, the question whether or not forming 'exact' customer representations of distant target groups is different compared to more proximate target groups has arisen. Literature in this field, especially within an innovation context, is very scarce. Therefore, in this study we uncover different areas of research related to cognitive distance. The focus is on the existence of cognitive distance and relevant theories as well as its application in the field of innovation management on an individual level. Our aim is to identify measures applicable to our research motivation of cognitive distance between product developers and distant target groups.

Methodology – co-citation analysis

We apply co-citation methodology to study the body of knowledge in research publications in order to identify the areas of research of cognitive distance. Technically, co-citation exists when two earlier documents are cited together in one or more documents published thereafter (Small, 1973). Assumptions in co-citation analysis are: (1) co-cited documents are likely to have similar or related content (Di Guardo & Harrigan, 2012); and (2) all citations are of the same significance (Verbeek, et al., 2002). The strength of co-citation is that it signifies the proximity between two cited documents. The proximity between documents can also be graphically represented by how the documents occupy the co-citation space when mapped in a graph (Di Guardo & Harrigan, 2012). Subsequently, key research clusters can be identified within the visualized knowledge

network to give an overview of the existing areas of research and knowledge gaps.

Co-citation can be conducted in two ways – co-author citation analysis or document co-citation analysis. In this study, we employ document co-citation analysis, to identify thought schools instead of co-working research clusters. We apply a 3 steps approach – data collection, data preparation, and cluster analysis, in which individual publications are the unit of analysis (Gmür, 2003; Herstatt & Schweisfurth, 2014) as shown in Figure 1. In order to identify the relevant publications in the field of cognitive distance, we conduct a web search in four major databases – Web of Knowledge, Google Scholar, EBSCO and PsycINFO. We use the following search phrase: "psychological distance" OR "subjective distance" OR "cognitive proximity" OR "cognitive distance". The search terms were identified through a key word analysis within some of the most relevant papers in the field. The publications are identified and selected accordingly in three steps as shown in Figure 1. We find 1265 records for the time period up till

2014 ('Identification' in Figure 1). The top cited search results of each database (top 300) are assessed for eligibility and irrelevant records are identified ('Eligibility'). We exclude papers that deal with other types of cognitive distances not relevant to our research question. These papers revolve around topic including social stigma and racism. This is achieved by using subject filters on each database as well as manual abstract analysis. Other filter criteria were also applied: (1) publication type and status is limited to peer-reviewed journal articles, book sections and books (2) language is limited to English and German. Needless to say, duplicates are also removed ('Screening'). This yields 67 publications to be included in the document co-citation analysis ('Included').

The bibliographies of 67 publications are manually extracted, checked for errors and standardized ('Extracted References'). The final data includes a total of 3654 citations distributed between 2405 bibliographical references from 1970-2014.

Figure 1 Steps of data collection and co-citation analysis, source: own analysis, steps adapted from PRISMA Flow Diagram (Moher, et al., 2009)
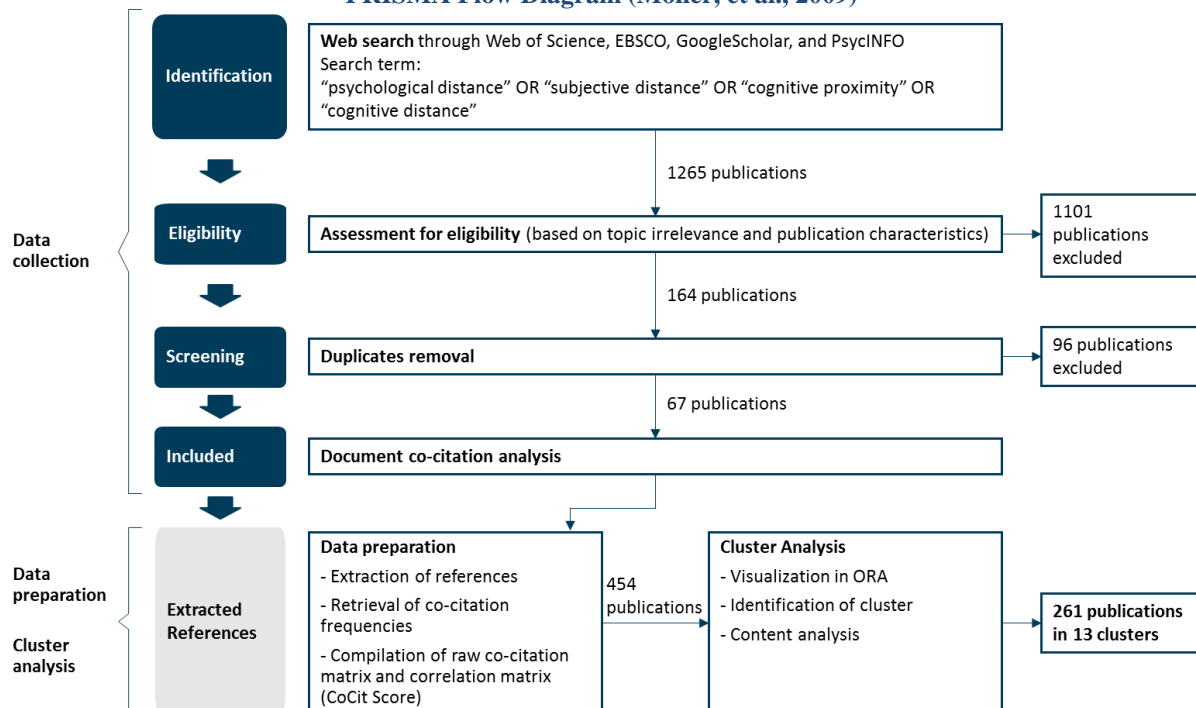
Subsequently, co-citation frequencies are retrieved. All bibliographical references that are co-cited are included to produce a raw co-citation matrix. This contributes to a 454 x 454 matrix consisting of 1674 citations distributed between 454 references (see step "Extracted References" in Figure 1).

CoCit scores are calculated to determine the proximity between two publications (Gmür, 2003; Schweisfurth, 2012). We applied CoCit scoring as the proximity measurement because it shows a high degree of robustness through linking the co-citation count to the minimum and mean count of the two individual citations. The calculated CoCit score has a value between 0 and 1, and can be calculated by using the following formula (Gmür, 2003):

$$CoCit_{AB} = \frac{(co-citation_{AB})^2}{minimum\ (citation_A; citation_B) \times mean\ (citation_A; citation_B)}$$

Based on this CoCit score matrix, the raw co-citation matrix is converted into a proximity matrix.

The prepared CoCit proximity matrix is subsequently imported into Organizational Risk Analyzer (ORA) (Carley, 2014). This is a tool developed at Carnegie Mellon to carry out dynamic meta-network assessment and analysis. The formation of a cluster indicates

Figure 2 Overview of co-citation network, source: own analysis
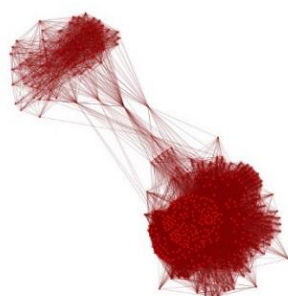
relatedness in content or key concept of the publications in the cluster. At a threshold of 0.7, a total of 13 clusters, containing 261 references

are identified. The content of each publication contained in the formed clusters is studied. The co-citation network is visualized in Figure 2. The two groups that made up the network can be separated briefly into two research fields, namely management-related (upper left group) and psychology-related papers (lower right group). By increasing a threshold value in between 0 and 1, the links lower than the threshold are hidden to show clusters of publications.

Clusters in cognitive distance literature

In total 67 articles published between 1965 and 2014 are selected based on two criteria: their relevance to the field of cognitive distance and total citation times in the document co-citation analysis. 61 of these articles included in the co-citation analysis are published in the recent 10 years.

Among these 67 articles, three authors – Yaacov Trope, Nira Liberman and Bart Nooteboom – stand out due to the high number of accumulated citations of their articles and the number of articles they have (co)published. Yaacov Trope and Nira Liberman have worked intensively, often in collaboration, in the research area of motivation and cognition. Bart Nooteboom has made significant contributions in the research field of innovation, entrepreneurship, alliances, trust as well as philosophy.

Approximately one third of the source articles are published by the Journal of Experimental Social Psychology (h5-index: 51, (Google Inc., 2015)), Journal of Personality and Social Psychology (75), as well as Psychology Science (85). The rest of the articles are obtained from 33 different journals from the fields of psychology, consumer research, innovation management science (e.g. Research Policy, h5-index: 73) and economics.

Cluster Distribution

In order to reveal different clusters/ thought schools of cognitive distance, a visualization is exerted (see Figure 3), generated by using ORA, a meta-network assessment and analysis tool from Carnegie Mellon University (Carley, 2014). The physical proximity between each cluster can be interpreted as an approximate indicator for the relatedness in terms of content features of the clusters. The size of a cluster is given in the number of nodes, which represents the number of publications in each cluster. The notion of cognitive distance is addressed in 8 of the clusters. Selected papers of each cluster are listed in the appendix. The main back bone of the network revolves around research in the area of social psychology (see Figure 4). A review of the clusters shows that research related to cognitive distance is quite heterogeneous and exhaustive, involving a wide range of research areas. Starting from the upper right quadrant, four clusters– "Spatial distance and construal levels", "Cognitive distance and construal level", "Interrelation between four dimensions of cognitive distance" and "Temporal distance

influencing behaviors and decisions" are found relatively close to each other. They share an overarching topic of construal level theory. In the lower right quadrant, there is a cluster related to subjective distance, which is more distant to the above mentioned group. All clusters occupying the upper left quadrant originate from the research field of business, economics and innovation management. The notion of cognitive distance is found in two of the clusters related to global teams and organizations. Other clusters are related to the field of neuropsychology, information processing, regional studies, strategy and alliances and creative cognition.

Cluster 1 – Cognitive distance and construal level

Construal level theory describes the effect that psychological distance has on the abstraction level of our thinking. The main four sub groups are spatial, temporal, social and hypothetical distance. According to construal level theory, people transverse psychological distance by

Figure 3 Overview of clusters, source: own analysis
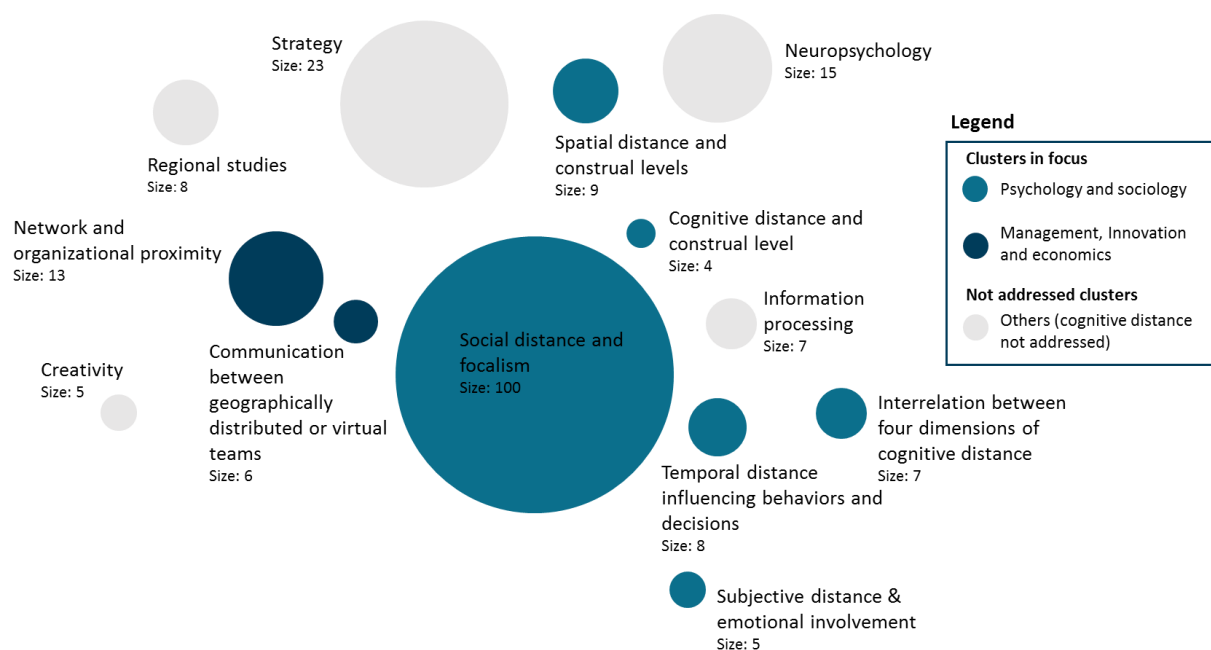
using abstract levels of mental construal. The higher the level of abstraction, the higher the perceived distance (Trope & Liberman, 2010).

The focus of this cluster is on the different dimensions of cognitive distance associate with construal level affect representation of social events, judgment and decision making. Both Henderson et. al. (2006) and Fujita et. al. (2006) extend the research on spatial distance to the representation of social events and judgments through different empirical studies. The results of both publications suggest that the tendency in using higher level construal increases with the spatial distance between the subject and the location of an event, which means that the event will be represented by its abstract and global features and the impact of low-level information on individuals' judgments and decisions will decrease instead. Additionally, Wakslak et. al. (2006) investigate another dimension of psychological distance, the effect of probability on construal of events. The relation between probability and construal is similar to the relationship found by Henderson and Fujita between spatial distance and level of construal. In the book "Social psychology: A handbook of basic principles", Liberman et. al. (2007) publish a review chapter of research done across behavioral sciences focusing on psychological distance. They highlight 3 important findings to support the conceptualized psychological distance as a framework to comprehend many social psychological phenomena: 1) different distance dimensions are interrelated, 2) distance in any dimension is connected to a higher construal level and 3) the effects of these different distance dimensions on prediction, evaluation and choice are to a certain extent reciprocal.

Of the above mentioned findings, most relevant for product development for distant target groups are following thoughts: Distance leads to higher levels of construals, leading to more abstract representations of Silver Agers needs. This can potentially lead to adverse effects in predicting exact needs/wants of the target group. As events in Silver Agers daily routines are distant in a sense that they are not experienced frequently, they are likely to be represented on a more abstract level by young developers, which influences adequateness of judgment (e.g. what needs are important). Spatial, temporal and probability distance dimensions are expected not to be relevant compared to product development for proximal target groups (e.g. peer groups).

Cluster 2 – Interrelation between four dimensions of cognitive distance

A more recent extension in the research field of mental construal level is found in this cluster. The majority of publications concentrate on interrelation of the conceptualized four dimensions of cognitive distance, i.e. spatial, temporal, social and hypothetical distance (see previous cluster description). Zhang and Wang (2009) look into the equality of all dimensions of distance. He manifests in empirical studies that an asymmetry exists between the spatial dimension and the other above mentioned dimensions. Fiedler et. al. (2012, p. 1020) challenge the construal level theory by designing favorable conditions for discounting effects to empirically examine how people judge spatial, temporal, hypothetical and social distances from the same set of targets. They find consistently positive correlations between all four dimensions of cognitive distance in both imagined events and previous experiences. The existence of such correlations between the four distances is a plea for a unitary subjective distance. They, thus, propose the idea that subjective distance is "rather an integral property that seems to be spontaneously and jointly triggered by information provided in all four modalities". Both, Zhang and Wang (2009) and Fiedler et. al. (2012) come to their conclusions principally based on patterns of assimilation. This means that when a distance is created in one dimension, and a person is subsequently asked to evaluate an unknown

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distance in another dimension, he/she has the tendency to infer a corresponding distance in the latter dimension. In contrast, Maglio et. al. (2013) find evidence in different judgment and decision tasks that suggest that experience of distance in one dimension will reduce sensitivity to any other distance evident. When a target is framed as distal, the subjective magnitude of additional distance in any dimension will shrink as compared to when the target is near. These findings are not contradicting those based on assimilation effect as the stimulus here is unambiguous – the additional distance is known between a proximal and a distal point, and the initial distance will make both points seem further away. In other words, the impact assessed in this case is not on the egocentric distance from such points on another dimension, but rather on the interval between these two points.

For product development these findings indicates that one sub category of distance might superimpose other distance effects, e.g. social distance in the case of Silver Agers. This is due to the fact that sensitivity for additional distances is low and multiple distance sub categories are eventually highly correlated anyways.

Cluster 3 – Spatial distance and construal levels
A good number of publications from this cluster share the common theme of spatial or physical distance as a construct of cognitive distance. Jia et. al. (2009) examine the consequences of spatial distance on creative cognition and insight problem solving. They find that enhanced creativity by spatial distance can have positive influence on creativity in solving problems. Henderson (2009) investigates the effect of spatial distance on beliefs about common goals. He finds that greater spatial distance influences group judgment as it leads people to believe that others who belong to a group are more unified by their common goals for the group. Interestingly, this occurs regardless if any social

distance arises between the individual and the group. Henderson implies that the judgment of a more unified group indicates a higher level of inferred 'groupness', which potentially raises the tendency of people to have stereotypes or prejudice-like representation of the group member. As for our case of Silver Agers, we do not see higher spatial distances compared to other target groups. Therefore, the relevance of spatial distance is expected to be low.

Cluster 4 – Subjective distance and emotional involvement
Ekman & Bratfisch find that, ceteris paribus, emotional involvement that subjects experience in something that happened in other cities is found to be inversely proportional to the square foot of subjective geographic distance (1965). This is further confirmed in a study by Bratfisch (1969). Lundberg & Ekman (1970) and Bratfisch et. al. (1971) demonstrate that between emotional involvement and subjective temporal distance, a relationship which bears resemblance to such inverse square root relationship, also exists. For our research interest, we find that emotional involvement decreases with cognitive distance. Being temporally distant from the Silver Age, younger developers might have less emotional involvement to events that happen in the lives of Silver Agers. Thus customer representation of younger developers might suffer, potentially leading to suboptimal outcomes in NPD process.

Cluster 5 – Social distance and focalism
In the main backbone cluster (see Figure 4) which contains publications in the field of social psychology, two research areas which address cognitive distance are identified. An area of research which received much attention in this cluster is on social distance, focusing on intergroup differences and perceived variability. The theoretical model of out-group homogeneity or in-group complexity suggests that individuals tend to form perception of their own in-group members as more diversified and

complex than out-group members. Evidence supporting this preposition is found consistently in the experiments of Jones et.al. (1981), Park & Rothbart (1982) and Park et. al. (1992). Linville (1982) uses age as in-group/out-group variable and finds similar effect in cognitive representation of in- and out-group. Interestingly, Brewer & Lui (1984) find that for the subject group of elderly, their category association of "other older people" (large category) also tends to be aged-stereotyped. These effects his might have strong implications on product development and customer representation in NPD. The out-group homogeneity effect might lead to product developers regarding Silver Agers as homogeneous target group. This can result in stereotypical representations of the target group, potentially leading to adverse NPD outcomes. As age is proved applicable to delineate groups (who is regarded as out-group), ceteris paribus, young aged product developers can potentially be subject to in-group/out-group effect in NPD for distant target groups.

Another aspect of this cluster is focalism which relates to temporal distance. Liberman et. al. (2002) empirically prove the principle of construal level theory in the temporal dimension. Objects, events and experiences in more distant future is represented in higher level of construal, in a more abstract and simpler way. Focalism influences predictions people make for distant future as they tend to focus more on "a focal event in more of a vacuum" (abstract, high level in terms of construal) and less on other routines, events and activities (concrete, low-level of construal) that would happen (Wilson, et al., 2000). Other prediction errors are the planning fallacy (Buehler, et al., 1994) and overconfidence in social prediction (Dunning, et al., 1990). Buehler et. al. (1994) request students to estimate the required time to complete their assignments and find that their predictions far exceed what they have completed in reality as

they tend to focus too much on the future task without considering similar past experiences.

An area of research in which temporal distance and social distance overlapped is the temporal effects on attributions and actor-observer bias are explored by Moore et. al. (1979), Burger (1986) and Funder & Van Ness (1983). Actor-observer bias results in phenomenon of fundamental attribution error, in which an observer tends to favor dispositional attributions (abstract, high level of construal) over situational attribution (concrete, low level of construal) when explaining the behavior of others. It is observed that this effect is moderated by temporal distance.

Focalism and temporal distance could both influence product developers representation of Silver Agers they traverse time. This might lead to a high level of abstraction of needs and an isolation of life environment as product developers picture themselves in the Silver Age.

Cluster 6 – Temporal distance influencing behaviors and decisions

This cluster further demonstrates the implications of temporal construal, especially on behavior and decision processes. Through studies, Liberman et. al. (2007) propose that the level of construal and time perspective are associated in a bi-directional relationship – events in distant future tend to activate higher level of construal, whereas events that are construed in higher level terms would be judged as pertaining to the more distant future. Herzog et. al. (2007) show that temporal distance to an action has an effect on people's attitudes towards the action, which may lead to the action in distant future favored more than in near future. Furthermore, temporal framing has an influence on the effectiveness of communication and marketing (Chandran & Menon, 2004). Concerning our research interest, findings of this cluster are not expected to have a major impact.

Cluster 7 - Communication between geographically distributed or virtual teams

The prevalence of geographically distributed or virtual teams has driven research focusing on the team dynamics and proximity between team members in management science studies. Webster & Staples (2006) compare the effectiveness of virtual teams to co-located teams. In this area a lot of emphasis has been placed on geographical distance or objective distance as it is critical to effective communication and team performance. Wilson et. al. (2008) propose to perceive proximity and distance in a broader sense rather than purely at the level of objective physical proximity. In their study, the paradox of feeling close to co-workers who are distant geographically is explored. A model of 'perceived proximity' is introduced in which communication and identification are highlighted as the core processes. These effects relate to social distance dimension. According to Wilson, in order to achieve a state of identification, team members should share a certain social category, entity or experience to establish a common ground. Hinds & Mortensen (2005) also share a similar view in their research focusing on examining conflicts in distributed teams which can effect team performance. They find that shared identity and shared content, especially achieved through spontaneous communication aids in moderating relationships as well as in conflicts.

Apart from managing conflict, maintaining trust in a geographically distributed or virtual team is challenging. Polzer et. al. (2006) look into how geographical fault lines impact conflict and trust between team members. Jarvenpaa & Leidner (1999) investigate how trust can be uphold in a team consisting of members in different location and culture through effective communication.
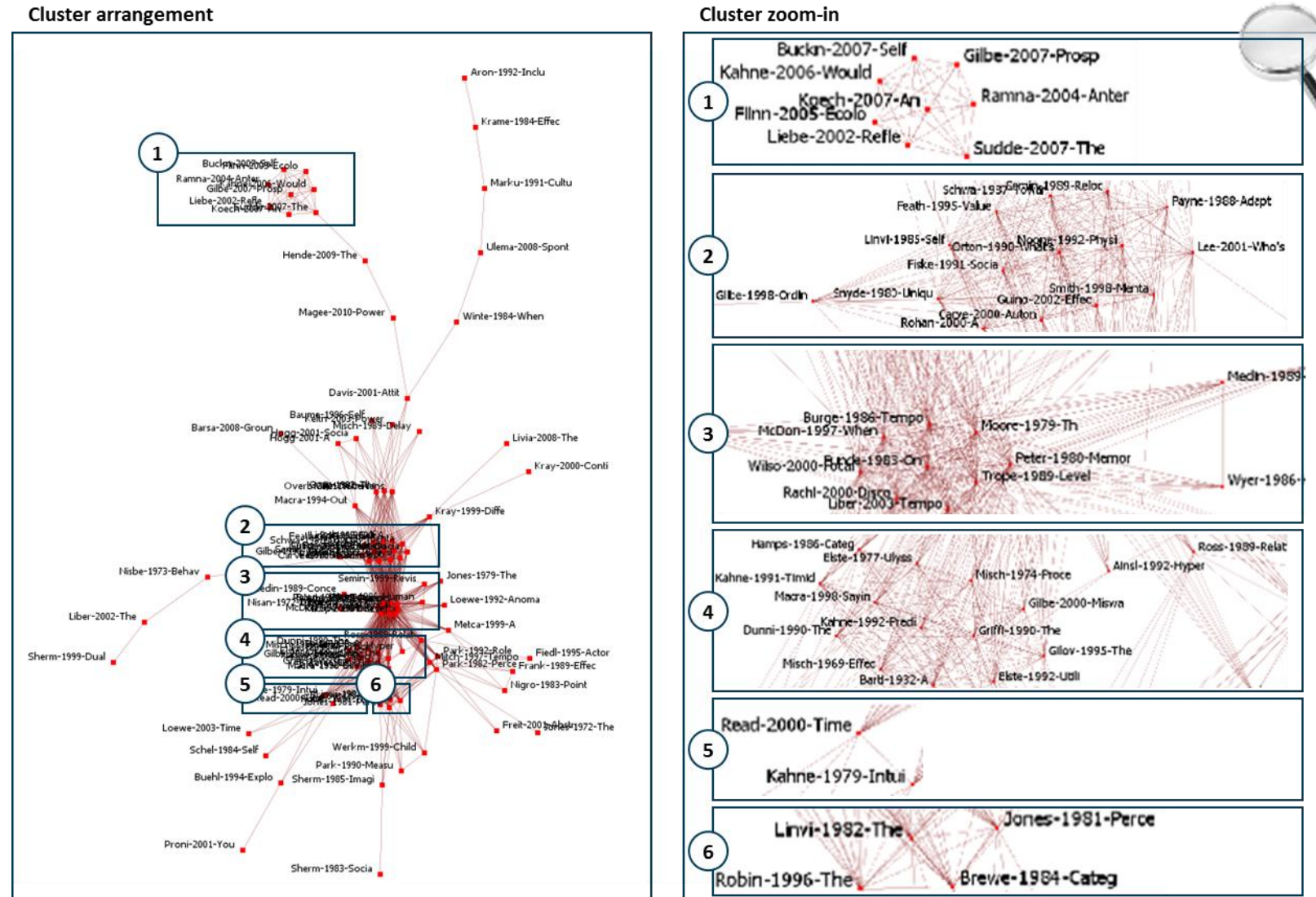
The studies of this cluster relate distance dimensions to team/productivity outcomes, which can be related to NPD outcomes for individual product developers. Here, especially spatial (geographical studies) and social distance dimensions are mentioned to have a significant impact on productivity outcomes.

Cluster 8 – Network and organizational proximity

The publications in this cluster deal with distance on an organizational level and its impact on activities such as learning, knowledge creation and innovation, especially within networks or alliances. Boschma (2005) and Nooteboom (2007) are two of the key authors in this regard. Nooteboom et. al. (2007) interpret cognitive distance through inter-firm differences in technological knowledge. They propose an inverted U-shaped effect of cognitive distance in alliances on innovation. That means that two cooperating companies benefit from a certain cognitive distance. Lower or higher distance reduce innovation potential through redundancy of knowledge (lower) or too different knowledge bases to efficiently cooperate (higher) Thus, when firms are searching for partners to form alliance, they face the challenge to find a partner at an optimal cognitive distance in order to optimized the trade-off between opportunities for novelty (at high cognitive distance) and sufficient mutual understanding (at low cognitive distance) needed to facilitate successful collaboration.

Boschma (2005) has critically assessed the role of proximity on organizational learning and innovation. He analyzed five sub categories: cognitive, organizational, social, institutional and geographical distance. He reasons that for effective learning and innovation, some level of proximity between actors or organizations, not too great or too little, is required. Cognitive proximity is considered to be mandatory to let learning processes happen; whereas the other four dimensions of proximity are seen as mechanisms that may connect actors within and between organizations, ensuring control and flexibility for implementation of new ideas.

Cluster arrangement

Cluster zoom-in

Figure 4 Cluster 5 – Social distance and focalism, source: own analysis

Balland (2012) analyzes empirically how organizations select their collaborators based on the five dimensions of distance. His empirical results indicate that geographical, organizational and institutional proximity support collaboration whereas cognitive distance has little impact as organizations tend to collaborate with partners with different knowledge base as well. By using German patent data, Cantner & Meder (2007) find empirically that the choice of collaboration partner is positively influenced by technological proximity between research partners (an indicator of cognitive distance), apart from reciprocal high value knowledge transfer as incentives and organizational knowledge and experience with research cooperation. Breschi et. al. (2003) investigate firms' technological strategy and find that firms' innovation activities are non-random, i.e. they are established across related fields which share similar knowledge bases.
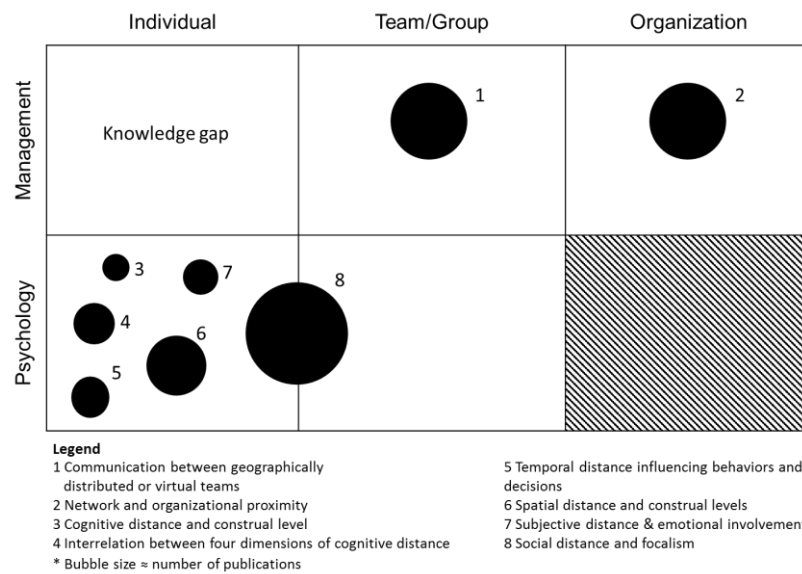
This cluster reveals facets of cognitive distance influencing innovation outcomes. Measures of distance are similarity of technology portfolios, or geographical distance. Although level of analysis is organizations and not individuals, the key theme is the degree of shared knowledge bases for mutual understanding, which is relevant for product developers in NPD for distant target groups as well (e.g. need-knowledge of target group).

Identification of knowledge gap

Our current analysis identified the latent structure of research fields underlying cognitive distance literature and identified heterogeneous findings from psychology, sociology, neurology, business and management, innovation and economics field of studies. The main streams of research are from innovation management and psychology research, which is the focus of the following passage.

We aim to link cognitive distance research to the individual situation that product developers face when envisioning product ideas based on their representation of the target group. For the further analysis, we will structure the papers following two criteria – level of analysis and research focus (psychological studies or management studies, see Figure 5). Level of analysis is of interest, since our aim is to provide insights on the effects of distance on individual developers. Research area is important, since our focus is on the consequences of distance (e.g. innovativeness, meeting customer preferences, etc.) as opposed to mere existence or influence factors on distance itself (as found in psychological studies).

Between the two fields of research (i.e. psychology and management studies), there are fundamental differences in terms of study design. In (innovation) management literature, most of the studies are empirical field studies or analysis of secondary data with focus on learning and innovation performance (Nooteboom, et al., 2007), team effectiveness and communication (Wilson, et al., 2008). As for psychology body of research, most studies were carried out through experimental/laboratory set-ups, focusing on sub categories of cognitive distance and their implications (Burger, 1986; Henderson, et al., 2006; Herzog, et al., 2007). Furthermore, the focus of research differs significantly. In innovation management studies, cognitive distance usually acts as an exogenous factor, which explains observed outcomes, e.g. higher team innovativeness, productivity, revenues. In the field of psychology, the concept of cognitive distances is applied two-fold, as an exogenous or endogenous factor. Thus, both causes (e.g. mental processes) and effects (e.g. changes of cognitive distance when multiple distance dimensions interfere with each other) of cognitive distance are researched. Our analysis reveals different foci of analysis level for both streams of literature. (Social) psychology studies

Figure 5 Research areas related to cognitive distance, source: own analysis

Legend
1 Communication between geographically distributed or virtual teams
2 Network and organizational proximity
3 Cognitive distance and construal level
4 Interrelation between four dimensions of cognitive distance
* Bubble size ≈ number of publications

5 Temporal distance influencing behaviors and decisions
6 Spatial distance and construal levels
7 Subjective distance & emotional involvement
8 Social distance and focalism

are, due to the nature of the research field, mainly conducted on an individual (e.g. perception of spacial distance) or a group level (e.g. in-group/out-group effects). To our knowledge, management science addressed cognitive distance only on a team/group level (e.g. influence of heterogeneous teams on innovation) and organization level (e.g. cognitive distance between firms' technology portfolios). Organizational level and psychology is shaded as it is not applicable in our understanding. Organizational psychology is rather concerned with processes within one organization, and not between two or more organizations as it is used in this context (inter-organizational). In conclusion, there is a knowledge gap of cognitive distance on an individual level in management science. Our analysis reveals that temporal as well as social distance sub categories of cognitive distance might have an impact on product developers. Thus, specific innovation performance effects of cognitive distance ought to be researched in the future.

Summary of cognitive distance concept application for product developers

In order to address this knowledge gap we discuss two options, i.e. application of existing cognitive distance research of psychological research and analysis of existing operationalizations in innovation management research (see Figure 6). As cognitive distance has been addressed in psychological research, one option is to evaluate the applicability of the findings and sub categories of cognitive distance to be applied for individual level cognitive distance research in new product development. Alternatively, we will discuss what prior innovation management research on team/group or organizational level can contribute on an individual level. Here, we will suggest potential operationalizations from an innovation management perspective. From psychology literature, we can conclude that cognitive distance has an impact on innovation or product development processes. To develop exhaustive user representations of distant target groups such as Silver Agers, product developers have to understand their point of view.

Figure 6 Application of psychological research of cognitive distance, source: own analysis
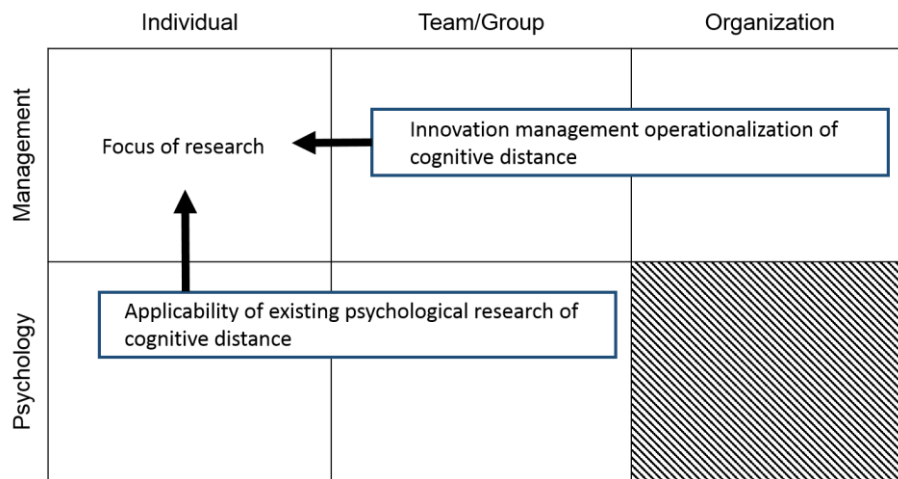
Nevertheless, it is impossible to experience potential needs of the old age now, since it will happen in the future. Therefore, one needs to transcend the here and now and form abstract mental representations of objects further in time, as depicted by the construal level theory and social psychology (e.g. focalism/in-group-out-group effects). We thus propose:

Product developers' individual cognitive distance to distant target groups influences product development outcomes (e.g. for Silver Agers)

To verify/falsify this proposition in an empirical context, it is necessary to find adequate operationalizations of cognitive distance. Concretely, one has to look into the sub categories of psychological distance of previous research (e.g. Liberman & Trope, 2014). Therefore, we evaluate the applicability of cognitive distance sub categories specifically for individual product developer's customer representation setting (see Table 1). The categories will be discussed along our illustrative example of young developers developing products for Silver Agers.

The social dimension of cognitive distance is expected to be the most important factor for product developers involved in product development for distant target groups, e.g. of Silver Agers.

Social distance exists inevitably between one self and any other person (self-versus others), but might be more pronounced regarding distant target groups. This implies that product developers experience the phenomenon of fundamental attribution error, in which dispositional attributes are focused on (abstract, high level of construal) over situational attribution (concrete, low level of construal) when referring to the behavior of e.g. Silver Agers. Thus, they would consequently overlook their specific needs in certain situations. Furthermore, due to age differences, different life experiences and social roles (grandparents, retiree etc.), there are dissimilarities in life styles, needs and wants, outlooks of life etc. (similar versus dissimilar other).

Generally, a younger developer is less familiar with the social group of Silver Agers than his/her own age group as there is less interaction (familiar versus unfamiliar other). Younger developers might also face the tendency of perceiving the Silver Ager group as more homogeneous with little or no diversity as a result of out-group homogeneity effect (in-group versus out-group). This is confirmed by studies highlighting age as a construct to delineate in-group/out-group perception

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Table 1 Sub categories of cognitive distance and its applicability for product development, source: own analysis based on Liberman & Trope (2014)

Sub categories of cognitive distance	Description	Significance for product/service development for distant target groups (e.g. Silver Agers)
Social distance	Self-versus others (e.g. describing oneself versus another person; decision-making for one self-versus for another person)	Developers are involved in perspective taking of others to understand their needs. In trying to reason the behaviors of others, they might experience an actor-observer bias.
	Similar versus dissimilar other	Distant target groups can be different from young corporate developers in many aspects (e.g. lifestyles, wants and needs) due to differences in age, social status etc.
	Familiar versus unfamiliar other	Developers are less familiar with distant target group as they tend to be active in different social circles
	In-group versus out-group	E.g. young developers might perceive Silver Agers (out-group) as more homogenous than own social group (in-group)
Time	Future (e.g. deciding something for tomorrow versus a year later; Picturing an event in the near versus distant future)	E.g. young developers need to imagine scenarios that may happen in their own Silver Age in distant future; imagining the future when the product will be available on the market
	Past (e.g. an object that exists in the past or in the future)	Travelling back into time is less important in product development for distant target groups
Space	Nearby versus faraway place (e.g. representing a route from own office to the nearest café versus from an office in another city to the nearest café)	Limited applicability in product development for distant target groups
Hypotheticality (probability)	High versus low probable events, circumstances, actions or tasks	Perception of experiencing physiological disabled or chronic diseases as improbable events; Underestimating the consequences of these events
	Real versus hypothetical (e.g. playing a demo game versus the real game)	Limited applicability in product development for distant target groups

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Temporal distance might also contribute to cognitive distance for product developers. In order to get a better representation of Silver Agers, product developers might also transcend temporal distance and imagine themselves in their Silver Age to make predictions and evaluations of their potential needs and preferences in the distant future. Focalism potentially oversimplifies the product developers own self-representation in the Silver Age.

The role of the spatial sub category of cognitive distance in product development for Silver Agers is rather limited, as we assume that Silver Ager customer groups are distributed evenly geographically as other customer groups and primary features of geographically distant Silver Agers are similar to closely-located Silver Agers. Hypothetical cognitive distance may arise when product developers are designing a product which they themselves are very unlikely to use, such as products targeted for certain physiological disabilities or chronic diseases. Developers will tend to form the perception that the chance to become disabled is very low. This may lead to an underestimation of the consequences of being disabled. For our research interest of measuring effects of cognitive distance for product developers, hypotheticality distance resulting from ageing-related mental or physical limitations can be subsumed in temporal distance. Age-related health declines most-likely occur in the Silver Age itself. Therefore, from a construal level theoretic perspective, it presents an additional distance – from developer's age now to Silver Age and 'then' from potentially fit to less fit health status. As sensitivity to additional cognitive distances is low (Maglio, et al., 2013), we assume that hypothetical distance has a rather neglectable additional impact on customer representation.

Our analysis of the psychological stream of literature suggests that cognitive distance for product development for distant target mainly unfolds on social and temporal sub category of cognitive distance as structured by construal level theory (Liberman & Trope, 2014).

To measure effects of cognitive distance on product development outcomes, one needs to find adequate measures for empirical testing. Therefore we analyze management related papers for operationalizations of cognitive distance as these relate cognitive distance to performance/innovation outcomes.

Innovation management empirical studies utilize a variety of operationalizations of cognitive distance, on team/group and organizational level. Team level is of high interest, as some measures are aggregated individual team member characteristics (e.g. age heterogeneity). On team/group level cognitive distance is measured in several ways. Wilson et. al. analyzed comments made by teammates which indicated mental assessment of how distant teammate are seen (2008). In their specific subsumption of several distance sub categories, Siebdrat et. al. measure subjective distance asking for perceived ease/effort to work in one location, virtuality and perceived frequency of communication in geographically dispersed teams (2014). In a team productivity study, Reagans et. al. measure the impact of team heterogeneity (2001), where heterogeneity, measured as organizational tenure across members, can be regarded as an approximation of social distance between team members.

On organizational level, technical cognitive distance between firms is indicated by the variable of 'partner dispersion' in a pharmaceutical industry study (Wuyts, et al., 2005). Here cognitive distance is operationalized by the ratio of the amount of partners over the number of agreements between firms (Ibid.). Similarly for ICT industry, cognitive distance is measured by the differences in firm size, diversification and profit margins whereas technical cognitive distance is measured by differences in the intensity and patterns of resources allocation by firms to R&D activities

(Ibid.). Alternatively, cognitive distance is calculated through the correlation of a firm's and its partner's technology profile. Technology profiles are collected from patent data, measured by the technology advantage or specialization of each firm in different patent classes (Nooteboom, et al., 2007).

We infer from innovation management literature, that there is no single operationalization for cognitive distance on the individual level that is applicable for our research focus. Nevertheless, on team level Siebdrat et. al. suggest that communication frequency/visibility can lower perceived (social) distance (2014), which we can build upon for the individual level.

Proposed measures for empirical innovation management studies

We identified two sub categories of cognitive distance that are expected to influence product developers' representation of distant target groups' user needs – temporal and social distance. Cognitive distance sub categories cannot be measured directly in empirical settings, therefore researchers have to find proxies for empirical testing. Temporal and social distance sub categories act on different levels. Temporal distance is related to each developer's individual distance to their own Silver Age. Thus, it reflects their own-self transcending a distance, which represents a self-referred movement in time. In line with other authors we propose to use one's own age, more specifically the age-difference to the Silver Age (e.g. 60 years old) as a proxy for temporal distance to Silver Ager target group.

Social distance in product development means, that product developers transcend from their own self-representation to distant/proximal customer representations. Thus, social distance/proximity in NPD is represented by the knowledge gap or level of detail/abstractness of knowledge between product developers and the

target group. Knowledge exchange is facilitated by trust-based interactions (Gertler, 2004). Thus, social distance depends on the existence and the strength of interpersonal links, i.e. to what extend individuals know each other and interact in private and/or professional contexts (Huber, 2012). Thus, for our purpose, we require a measure that incorporates networks of personal relationships (as opportunities for knowledge exchange) and quality of these exchanges from an individual actor's perspective (i.e. product developer).

For this reason we suggest applying social capital theory for empirical validations of social distance. As opposed to financial capital (stocked, exchangeable) and human capital (stock of expertise), social capital does not reside in individuals. Social capital is rather the goodwill within the relations between individuals and organizations. Its source lies in the structure and in the content of these social relations. The actor benefits from the information flow, influence, solidarity that the network makes available (Adler & Kwon, 2002). Thus, an actor's social capital can be seen as the sum of potential resources which are both derived from and accessible through their network of relations (Nahapiet & Ghoshal, 1998). High social capital with the target group, i.e. large networks, high communication frequency, close relations, present an opportunity for product developers to accumulate customer need-knowledge and lower cognitive distance. Thus, product developer's social capital to (distant) target groups can be seen for an inverse proxy to social distance. Lower social distance leads to less abstracts customer representations in NPD, which in return might lead to higher product innovation success.

Conclusion

Summary of findings

We utilize objective bibliometrics to identify and visualize different research areas within the diverse body of cognitive distance literature aiming to detect conceptual subdomains (particular theories or schools of thought) applicable for product development. Our findings offer several interesting conclusions. Generally, the notion of cognitive distance has received much attention from researchers in the field of psychology and sociology on an individual level, and from management, innovation and economics scholars on a team and organizational level. Through co-citation analysis, we argue that there is a knowledge gap in research addressing cognitive distance in innovation management field – relating product developers' distance to target groups to NPD outcomes. We acknowledge that prior research regarding cognitive distance and construal level theory from the psychology discipline might affect product developers. Among the four conceptualized dimensions of cognitive distance in construal level theory, the temporal and social dimension in particularly could be pivotal to hypothesized effects, as we have revealed in the discussion of cognitive distance sub categories in the Silver Agers example. Due to the fact, that an adequate operationalization for social sub category for empirical management studies is yet to be found, we propose to measure individual developer's social proximity/distance to target groups through established measures of social capital theory. This implies that higher social capital with members of the distant target group facilitates customer need-knowledge transfer and accumulation, thus reducing social distance for product developers. Increased customer need-knowledge will eventually turn into more accurate product/service ideas in NPD.

Practical implications

Independent of the above mentioned drawbacks, borrowings from psychological literature, specifically construal level theory, might help improve product developer's quest to obtain an accurate user representation when developing for distant target groups. Needless to say, cognitive distance may not be removed entirely, but its impact can certainly be reduced. In the process of forming customer representations or designing a product, focusing on concrete construal of the target group (e.g. Silver Agers) would be a direct countermeasure to lower the impact of cognitive distance. One creative methodology to inject accurate and detailed information about users is a notion called personas, which are "fictitious, specific, concrete representations of target users" (Pruitt & Adlin, 2006, p. 11).

Our second suggestion is to increase familiarity of product developers with members of the target group. Through increased familiarity, customer knowledge and preferences become apparent, lowering level of construals when referring to them in NPD projects. Practically, this means promoting creation of professional and private networks with members of the distant target group in focus. The embedded value of these networks is referred to as social capital (Coleman, 1988; Burt, 2000; Rost, 2011). With a more extensive network, it is expected that the frequency and chances of interaction between the product developers and Silver Agers will increase, both at work and in a private setting. Social distance may then be decreased as familiarity increases and accurate user representations are increased.

Thirdly, in line with product development literature, capable target group members can be involved directly in the product development process by different means (Kaulio, 2010; Kujala, 2003). This should prevent misperceptions directly in the ideation phase and help to elicit specific, nuanced needs (Östlund, 2011). Referring to Silver Agers, promising candidates

could comprise retired engineers, designers or technology enthusiasts, potentially showing lead user characteristics and empathic character traits to reflect on other Silver Agers in co-creation sessions.

Need for future research

This study is of interest for product developers and scholars who are working in the field of innovation and potentially psychology. Although existing literature indicates adverse effects of cognitive distance on abstractness/level of detail in mental processes, no study has empirically explored cognitive distance effects on NPD outcomes on an individual level, specifically which sub categories specifically constitute distance in product development. Therefore, the advanced proposition should be operationalized and tested in future studies by either scholars from the management sciences disciplines or psychology and sociology and extend theory in the field of innovation management.

Furthermore, it can be worthwhile to explore which dimensions of distance influence product developers in their innovation processes. For example, the temporal dimension of cognitive distance in product development could be explored by measuring age as a variable. Two subject groups of product developers (young and older) could be asked to describe their representation of two groups of target users (e.g. Millennials and Silver Agers). The concreteness/abstractness of the descriptions can then be analyzed and used as an indicator for low/high level of construal and cognitive distance. Additionally, social distance effects could potentially be studied utilizing social capital operationalizations in order to measure proximity/familiarity to/with members of distant target groups.

Companies willing to exploit the emerging Silver Markets efficiently, are urged to develop products that serve this distant target group's needs. For product development, that means

accurate customer representations should be the foundation of future products. For individual product developers, psychological research indicates that cognitive distance might be in the way to meet exact customer requirements. Innovation management related research needs to address this issue and reveal what distance dimensions are most critical on the individual level and how potential adverse effects can be mitigated.

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Appendix – Selected papers from 8 focus clusters

Cluster	Author	Year	Title	Journal
Psychological distance and construal level	Wakslak, C. J., Trope, Y., Liberman, N., & Alony, R.	2006	Seeing the forest when entry is unlikely: Probability and the mental representation of events.	Journal of Experimental Psychology: General
	Henderson, M.D., Fujita, K., Trope, Y., & Liberman, N.	2006	Transcending the ''here'': The effect of spatial distance on social judgment.	Journal of Personality and Social Psychology
	Fujita, K., Henderson, M. D., Eng, J., Trope, Y., & Liberman, N.	2006	Spatial distance and mental construal of social events.	Psychological Science
	Liberman, N., Trope, Y., & Stephan, E.	2007	Psychological distance. In E.T. Higgins & A.W. Kruglanski (Eds.), Social psychology: A handbook of basic principles (2nd ed., Vol. 2, pp. 353–383). New York: Guilford Press.	Book
Interrelation between four dimensions of psychological distance	Maglio, S. J., Trope, Y., & Liberman, N.	2013	Distance from a distance: Psychological distance reduces sensitivity to any further psychological distance.	Journal of Experimental Psychology: General
	Fiedler, K., Jung, J., Wänke, M., & Alexopoulos, T.	2012	On the relations between distinct aspects of psychological distance: An ecological basis of construal-level theory.	Journal of Experimental Social Psychology
	Zhang, M., & Wang, J.	2009	Psychological distance asymmetry: The spatial dimension vs. other dimensions.	Journal of Consumer Psychology
Spatial distance and construal levels	Jia, Lile, Edward R. Hirt, and Samuel C. Karpen	2009	"Lessons from a Faraway Land: The Effect of Spatial Distance on Creative Cognition,"	Journal of Experimental Social Psychology

	Henderson, M.D., Fujita, K., Trope, Y., & Liberman, N.	2009	Psychological distance and group judgments: The effect of physical distance on beliefs about common goals.	Personality Soc. Psych. Bull
Subjective distance and emotional involvement	Bratfisch, O.	1969	A further study of the relation between subjective distance and emotional involvement.	Acta Psychologica
	Bratfisch, O., Ekman, G., Lundberg, U., & Krucer, K.	1971	Subjective temporal distance and emotional involvement.	Scandinavian Journal of Psychology
	Ekman, G. and O. Bratfisch	1965	Subjective distance and emotional involvement; a psychological mechanism.	Acta Psychologica
	Lundberg, U. and G. Ekman, G.	1970	Emotional involvement while anticipating an examination. A psychophysical study.	Perceptual and Motor Skill
Psychological social and temporal distance	Liberman, N., Sagristano, M. D., & Trope, Y.	2002	The effect of temporal distance on level of mental construal.	Journal of Experimental Social Psychology,
	Funder, D. C., & Van Ness, M. J.	1983	On the nature and accuracy of attributions that change over time.	journal of Personality
	Moore, B.S., Sherrod, D. R., Liu, T. J., & Underwood, B.	1979	The dispositional shift in attribution over time.	Journal of Experimental Social Psychology
	Burger, J. M.	1986	Temporal effects on attributions: Actor and observer differences.	Social Cognition
	Wilson, T. D., Wheatley, T., Meyers, J. M., Gilbert, D. T., & Axsom, D.	2000	Focalism: A source of durability bias in affective forecasting.	Journal of Personality and Social Psychology
	Dunning, D., Griffin, D. W., Milojkovic, J., & Ross, L.	1990	The overconfidence effect in social prediction.	Journal of Personality and Social Psychology

	Linville, P. W.	1982	The complexity-extremity effect and age-based stereotyping.	Journal of Personality and Social Psychology
	Brewer, M. B., & Lui, L.	1984	Categorization of the elderly by the elderly: Effects of perceiver's category membership.	Personality and Social Psychology Bulletin
	Jones, E. E., Wood, G. C., & Quattrone, G. A.	1981	Perceived variability of personal characteristics in ingroups and outgroups: The role of knowledge and evaluation.	Personality and Social Psychology Bulletin
	Park, B., Ryan, C. S., & Judd, C. M.	1992	Role of meaningful subgroups in explaining differences in perceived variability for in-groups and out-groups.	Journal of Personality and Social Psychology
	Park, B., & Rothbart, M.	1982	Perception of out-group homogeneity and levels of social categorization: Memory for the subordinate attributes of in-group and out-group members.	Journal of Personality and Social Psychology
	Buehler, R., Griffin, D., & Ross, M.	1994	Exploring the "planning fallacy": Why people underestimate their task completion times.	Journal of Personality and Social Psychology
Temporal distance	Malkoc, S. A., Zauberman, G., & Ulu, C.	2005	Consuming now or later? The interactive effect of timing and attribute alignability.	Psychological Science
	Herzog, Stefan M., Joachim Hansen, and Michaela Wanke	2007	Temporal Distance and Ease of Retrieval	Journal of Experimental Social Psychology
	Liberman, N., Trope, Y., McCrea, S. M., & Sherman, S. J.	2007	The effect of level of construal on the temporal distance of activity enactment.	Journal of Experimental

				Social Psychology
	Chandran, Sucharita, and Geeta Menon	2004	When a Day Means More than a Year: Effects of Temporal Framing on Judgments of Health Risk	Journal of Consumer Research
Communication between geographically distributed or virtual teams	Hinds PJ, Mortensen M	2005	Understanding conflict in geographically distributed teams: The moderating effects of shared identity, shared context, and spontaneous communication.	Organisational Science
	Webster, J., and D. S. Staples.	2006	Comparing virtual teams to traditional teams: An identification of new research opportunities.	Research in Personnel and Human Resources Management
	Jarvenpaa, S., and D. Leidner.	1999	Communication and trust in global virtual teams.	Organization Science
	Wilson, J. M., M. B. O'Leary, A. Metiu, and Q. R. Jett.	2008	Perceived proximity in virtual work: Explaining the paradox of far-but-close.	Organization Studies
	Polzer, J. T., C. B. Crisp, S. L. Jarvenpaa, and J. W. Kim.	2006	Extending the faultline concept to geographically dispersed teams: How colocated subgroups can impair group functioning.	Academy of Management Journal
Network and organizational proximity	Nooteboom, B., Van Haverbeke, W., Duysters, G., Gilsing, V., van den Oord, A.	2007	Optimal cognitive distance and absorptive capacity.	Research Policy
	Drejer I, Vindig A	2007	Searching near and far: determinants of innovative firms' propensity to collaborate across geographical distance.	Industry and Innovation
	Cantner, U., Meder, A.	2007	Technological proximity and the choice of cooperation partner.	Journal of Economic Interaction and Coordination
	Balland, Pierre-Alexandre.	2012	Proximity and the Evolution of Collaboration Networks: Evidence from Research and Development Projects Within the Global Navigation Satellite System (GNSS) Industry	Regional Studies

	Rallet, A., & Torre, A.	1999	Is geographical proximity necessary in the innovation networks in the era of global economy?	Geo Journal
	Boschma, R. A.	2005	Proximity and innovation: A critical assessment.	Regional Studies
	Breschi, S., Lissoni, F., Malerba, F.	2003	Knowledge-relatedness in firm technological diversification.	Research Policy