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Depressive Symptoms and Activity
in a Sample of Nursing Home Residents

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Contents

List of Publications

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Extended Abstract

Objectives. The present dissertation focused on nursing home (NH) residents' depressive symptoms and the role of social activity, functional ability, and physical activity training in explaining these symptoms. First, the interplay of residents' basic competence (BaCo), expanded everyday competence (ExCo), and depressive symptoms was considered (Study I). The mediating role of perceived control was also examined. Building on the importance of BaCo for residents' depressive symptoms, the effect of a BaCo-enhancing physical activity program (LTCMo) on residents' depressive symptoms development was investigated (Study II). Furthermore, to better understand the roles of BaCo and ExCo in residents' depressive symptoms, ExCo-related activities were differentiated into contact with co-residents and staff, and participation in organized activities. Their respective enjoyabilities were also considered longitudinally (Study III). Finally, the role of depressive symptoms in predicting residents' sensor-based life-space was explored (Study IV).

Design. Data were drawn from the study *Long-Term Care in Motion* (LTCMo; Current Controlled Trials ISRCTN96090441), which was part of EU's Social Innovations Promoting Active and Healthy Aging funding scheme [HEALTH.2012.3.2-3]. LTCMo installed a physical activity training in two NHs in Heidelberg. The intervention aimed at promoting both residents' physical activity behavior and healthy aging at large. It offered multiple training components (BaCo-related group training and optionally serious games training, or individual training) and allowed residents to choose in which components they wished to participate. After the study intervention, the training was handed over to activity coordinators in the NHs, who implemented the training sustainably. Residents were followed for three (NH 1) and four (NH 2) measurement occasions each three months apart (waiting control group in NH 2). At each measurement occasion, new residents were allowed to enter the study. The presented studies were either based on cross-sectional (Studies I and IV) or on longitudinal data, which included the examination of the LTCMo training effect on residents' depressive symptoms (Studies II and III).

Participants. All permanent, non-palliative residents in the homes were approached and those who (or whose legal representative) gave written informed consent, participated. The number of participants considered in the various papers differed depending on the outcome and the study design. For the cross-sectional studies only referring to residents' first measurements (Studies I and IV), the number of participants ranged between 65 and 196, with fewer residents particularly for the sensor-based life-space assessment in Study IV. In the longitudinal studies (Studies II and III), a maximum of 163 residents with 434 measurement points was considered. At pretest, 41% of the sample resided in NH 1 and 16% lived on dementia-care units; 70% were female. On average, residents were 84 years old (range 53–100), showed moderate cognitive impairment ($M_{\text{Mini-Mental State Examination}}$ = 20; range = 0–30), and depressive symptoms below the cut-off for clinical relevance ($M_{\text{GDS-12R}}$ = 3; range = 0–11). Across study time, 17% of pretest participants dropped out, 86% of which were death-related drop-outs.

Methods. Measurements used in the present dissertation include resident interviews (e.g., depressive symptoms, activity enjoyability, cognitive performance), functional performance tests (e.g., BaCo-related gait speed), proxy ratings (e.g., ExCo-related activities), information from the obligatory care documentation in the NHs (e.g., demographic data), and sensor-based indoor tracking of residents (life-space). Depressive symptoms as measured with the Geriatric Depression Scale–Residential (GDS-12R) were the main outcome for Studies I to III. While they were modeled as latent variables using item response theory in Study I, they were modeled as gamma-distributed scale scores in Studies II and III. Study IV considered several life-space dimensions as outcomes, namely the time away from the resident's room and the number of life-space zone changes (transits). For the cross-sectional studies, structural equation models (Study I) and linear regressions (Study IV) with full information maximum likelihood estimations were used. For the longitudinal studies, generalized linear mixed models were used.

Results. Less BaCo impairment and more ExCo-related activities were found to predict fewer depressive symptoms cross-sectionally (Study I). The paths between the latent factors were robust when cognitive impairment, home affiliation, sex, and age were controlled for. Perceived control mediated the effect of BaCo, but not ExCo, on residents' depressive symptoms. Focusing on the effect of LTCMo's BaCo-enhancing training program showed that residents not participating in the intervention experienced steadily increasing depressive symptomatology across study time, while residents receiving the training maintained their pretest level of depressive symptoms throughout (Study II). The training group suffered from significantly fewer depressive symptoms than the non-training group both at posttest and at follow-up. The effect was robust when controlling for home affiliation, sex, age, living on dementia-care unit, and perceived internal and external control which were significant predictors in Study I. When ExCo-related activities were investigated differentially as longitudinally-framed predictors of depressive symptoms (Study III), activity-specific patterns emerged. For self-initiated co-resident contact, the interaction of contact frequency and enjoyability predicted fewer depressive symptoms with fewest symptoms for those residents who frequently had enjoyable co-resident contact. For self-initiated staff contact, however, only marginal main effects of frequency and enjoyability emerged. And for participation in organized in-home activities, participation enjoyability rather than frequency predicted fewer depressive symptoms (Study III). Conforming to Study II, the training effects emerged and were robust to controlling ExCo-related activity frequency, enjoyability, and additional covariates (Study III). Finally, regarding life-space, residents with more depressive symptoms spent significantly less time away from their own room compared to residents with fewer depressive symptoms (Study IV). Depressive symptoms did not, however, affect the number of life-space transits.

Conclusions. Findings support that BaCo impairment and ExCo-related activities, their respective enjoyabilities, and physical activity-enhancing training all are important for NH residents' depressive symptoms. Given sufficient replication, these insights may guide future intervention research and, in the long run, help to create more effective interventions for maintaining low levels of depressive symptoms in NH residents. Beyond the present findings, future research may investigate the potential of combining enjoyable co-resident contact and a physical activity-enhancing training to reduce or maintain the level of residents' depressive symptoms. Future research may also focus on assumed underlying processes to better identify residents at risk of developing depressive symptoms. As emerging in the present studies, perceived control may be a promising candidate process variable to consider.

Overview

The present dissertation is structured as follows: Chapter 1 provides the theoretical and empirical background to better understand NH residents' depressive symptoms (including the role of the NH as a specific setting for older adults, definition of depressive symptoms, prevalence and relevance of residents' depressive symptoms), introduces a conceptual framework of depressive symptoms in the NH, and illustrates how this framework can be expanded to answer the research questions addressed in the dissertation's studies. Chapter 1 ends with an overview of the open research questions targeted in this dissertation and the relevant, respective hypotheses. Chapter 2 addresses overarching methodological considerations which include a setting description, design-related issues, as well as data-analytical questions and the respective decisions. The four dissertation's manuscripts follow in Chapters 3 to 6 (Studies I to IV). Finally, Chapter 7 summarizes and discusses the studies' results as a whole.

1

Theoretical Background and Study Aims

1.1 Depressive Symptoms in Nursing Home Residents

As the present dissertation focuses on nursing home (NH) residents' depressive symptoms, specifics of the NH environment and the definition of depressive symptoms in this context will first be explained.

1.1.1 Specifics of Nursing Homes and Nursing Home Residents

A total of 764,431 persons received long-term care in Germany in 2013, which amounts to approximately 1% of the German population (Statistisches Bundesamt, 2015). The absolute number of dependent older persons receiving institutionalized care in Germany has increased by 23% between 1993 and 2013 (Statistisches Bundesamt, 2015) and is predicted to remain high or even increase due to the ongoing rapid increase in the number of older adults in advanced old age (European Commission & Economic Policy Committee, 2012).

To better understand NH residents' depressive symptoms, it is necessary to understand the specifics of this setting. A NH can generally be characterized as "a facility with a domestic-styled environment that provides 24-hour functional support and care for persons who require assistance with activities of daily living (ADLs) and who often have complex health needs and increased vulnerability."[1] (Sanford et al., 2015, p. 183) Accordingly, NH residents constitute a unique and highly fragile population. For example, overall bodily vulnerability as indexed by the concept of frailty is twofold higher and ICD-10-diagnosed dementia is even 19-fold higher in NH residents compared to community-dwelling adults aged 65+[2] (Bandeen-Roche et al., 2015; Hoffmann, Kaduszkiewicz, Glaeske, van den Bussche, & Koller, 2014). Indeed, every second resident was found frail in a recent meta-analysis (Kojima, 2015). Moreover, residents are close

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[1] Sanford et al. (2015) elaborated that the terms *nursing home* and *long-term care* are used synonymously in Germany as opposed to other countries, where multiple facilities may be termed NHs. In the present dissertation, the term NH always refers to long-term care facilities.

[2] This study reported prevalence rates by age, sex, and place of residence. However, it neither controlled for social embeddedness nor for cognitive status, which might explain part of the large difference. However, the finding shows the vulnerability of NH residents compared to community-dwelling older adults.

to the end of their lives with a median length-of-stay in the NH of only three months for men and eight months for women (though with large *SD*s; Kelly et al., 2010).

Notably, living in a NH has changed during the last decades. While Goffman (1961) counted NHs among *total institutions*, recent research coined the phrase *pseudo total institutions* (Heinzelmann, 2004) for German NHs as residents are, i.a., free to furnish their private rooms to a large extent; to leave the institution if physical or cognitive impairments do not hinder them; to participate in offered activities; to visit co-residents; and to receive visitors. However, some institution-specific totalistic features still exist, e.g., daily activities are basically concentrated in one place (Jansen et al., 2017); follow a strict organizational schedule (e.g., fixed times for self-care, meals), and residents and staff are discrete groups with staff controlling residents' daily life (Heinzelmann, 2004).

Calkins (2001) developed an integrated model of the environment in a dementia care setting able to be applied to NHs at large as it leaves opportunities to fill overarching concepts with NH or dementia-care-specific content. That is, Calkins differentiated between the individual resident and his/her physical, social, and organizational environment. Furthermore, she followed a hierarchical systems approach naming exemplary variables, which operate on each of these environmental levels (Calkins, 2001). In the NH context, dementia-related disorders, frailty, and depression may be relevant variables at the *individual* level (Hoffmann et al., 2014; Kojima, 2015; Meeks, Vahia, Lavretsky, Kulkarni, & Jeste, 2011). Additionally, resource-oriented factors like religious affiliation and values, abilities, and motivations characterize an individual and thereby potentially influence an outcome like depressive symptoms. With respect to the *physical environment*, the institutions' building structure and architectural features, the institutions' and residents' furniture, as well as properties like light, noise, and temperature are examples for important determinants eventually influencing residents' outcomes. Concerning the *social environment*, the availability and characteristics of interaction partners like nurses, co-residents, and visitors impact on residents' social interaction possibilities and experiences. Also, interaction partners' characteristics like sensory impairment and dementia may complicate social interactions among residents (Park, Zimmerman, Kinslow, Shin, & Roff, 2012), while activity groups offered in-home provide chances for meeting residents with similar interests and abilities, thereby influencing residents' outcomes. As for the *organizational environment*, the number of residents in the NH, the staffing ratio, and also institutional rules and routines influence residents' behavior. For example, if staff values *safety first*, then highly impaired residents may be judged to require permanent supervision, which may result in placing them in sight of the nurse's station. To take another example, wandering behavior of persons with dementia may be judged to require a permanent barrier to avoid leaving the unit, which may restrict residents' life-space. Furthermore, as organizational environments, NHs have rather strict daily routines including waking and washing, mealtimes, and bedtime, and scheduled although voluntary activities between mealtimes which structure residents' behavior across the full day. In sum, NHs are systems with specific physical-environmental, social, and organizational characteristics which interact with individual residents and their resources, preferences, and abilities or disabilities. Any research conducted in NHs must take these special characteristics into account.

1.1.2 Prevalence of Nursing Home Residents' Depressive Symptoms

The present dissertation focusses on NH residents' depressive symptoms. To clarify how depressive symptoms differ from depression as a psychiatric disease diagnosis, the concepts will be defined in the following box.

Major depressive disorder (MDD) according to DSM-5 criteria (American Psychiatric Association, 2013) requires the presence of at least five out of nine depressive symptoms (depressed mood, loss of interest or pleasure, significant weight loss or increase, insomnia or hypersomnia, psychomotor agitation or retardation, loss of energy, inappropriate guilt, concentration problems, suicidal ideation), which shall be present for at least two weeks and cause clinically significant suffering. Either depressed mood or loss of interest or pleasure has to be present to warrant a diagnosis. Furthermore, the symptoms must neither be attributable to physiological effects of a substance or a medical condition, nor to schizophrenia spectrum or other psychotic disorders. A (hypo-)manic episode must never have been present. For details, see American Psychiatric Association (2013).

Minor depressive disorder (MinD) according to DSM-IV research criteria (American Psychiatric Association, 1994) requires the presence of only two to four out of the nine depressive symptoms named in MDD. The symptoms must not be better accounted for by bereavement. Furthermore, the inclusion and exclusion criteria are similar, though MDD must not have occurred at any point in lifetime in order to diagnose MinD.

Subthreshold depression (SubD) is predominantly used by researchers who operationalize the construct differently. Cuijpers and Smit (2004) reviewed these operationalizations systematically and named three criteria that are commonly used: a definition, a recency criterion, and the inclusion or exclusion of lifetime MDD. In previous literature, SubD was defined as MinD; as mood problems with only one other symptom, or as mood problems with/without other symptoms. The recency criterion commonly consisted of current symptoms, of symptoms during the last year, or of symptoms at any point in lifetime.

Clinically relevant symptoms as defined in this dissertation refer to an individual score above the cut-off score on a depressive symptoms scale. This cut-off is typically defined as the optimal trade-off between sensitivity and specificity from receiver operating characteristic curves. The cut-off score is population-dependent.

Commonly, depression research focusses on MDD (American Psychiatric Association, 2013). In the aging population, however, less severe manifestations of depression such as MinD (American Psychiatric Association, 1994) and SubD are also prominent research topics. However, the constructs are less well-defined than MDD. While MinD criteria appeared in a former DSM version, the current DSM-5 discards them. Still, epidemiologic depression research considers MinD as it allows quantifying the amount of persons suffering from depressive symptoms that impair important areas of functioning without meeting the criteria for MDD. For example, an older person suffering from two rather than four depressive symptoms plus depressed mood would be diagnosed as suffering from MinD. A broader and even less well-defined category is SubD. Researchers used manifold nomenclature for SubD including subthreshold depression, subsyndromal (symptomatic) depression, subclinical depression, and nonspecific depressive symptoms (Rodríguez, Nuevo, Chatterji, & Ayuso-Mateos, 2012) with likewise heterogeneous operationalizations. In an attempt to extract the common kernel, Cuijpers and Smit (2004) identified three sources of heterogeneity (see definition box above). Accordingly, persons suffering from SubD are, e.g., persons suffering from depressive symptoms but neither from depressed mood nor from a loss of interest or pleasure; or adults suffering from one and only one of those exact symptoms; or adults suffering from two to four depressive symptoms when MDD had occurred in lifetime. Importantly, some counted MinD and clinically relevant depressive symptoms among SubD (Cuijpers & Smit, 2004), while others excluded MinD in their SubD definition (Judd, Rapaport, Paulus, & Brown, 1994), and still others introduced non-major depression as a superordinate concept (Vahia, Kulkarni, Meeks, & Jeste, 2013). Clarification and consensus are clearly needed as this heterogeneity in the investigated constructs hampers the comparability of prevalence estimates and of results on causes and consequences of depression.

In NHs, the prevalence of MDD was found to range from 6% to 24% (Hyer, Carpenter, Bishman, & Wu, 2005). SubD in NH residents, however, is more common than MDD with a median ratio of 2.5:1 (Meeks et al., 2011). Point estimates of SubD and MinD together range from 33% to 61% of NH residents. Meeks et al. (2011) noted an increasing prevalence of depressive symptoms from community-dwelling older adults to older primary care and medical inpatients to NH residents, who had the most depressive symptoms. During one year, 9% converted from no depression or MinD to possible MDD and 7% converted from no depression to MinD, while only 5% remitted from MDD to no depression in a NH sample (Parmelee, Katz, & Lawton, 1992). These epidemiological data highlight how widespread depressive symptoms are in the NH setting. They also show how relevant it may be to gain a better understanding of both the factors contributing to depressive symptoms and of the opportunities to prevent the development of depressive symptoms.

To better understand the differences in estimated prevalence rates, the difference between categorical and dimensional diagnostics has to be considered alongside the differences in concept definitions. On the one hand, clinicians use categorical diagnostics to categorize a patient as suffering versus not suffering from pathologic depression (e.g., MDD, MinD); on the other hand, researchers use dimensional diagnostics to assess the quantity of depressive symptoms from which a person suffers. Accordingly, dimensional diagnostics enable precise estimation of the severity of depressive symptoms and enable the investigation of depressive symptoms in non-pathological persons. Additionally, a person's score on a dimensional scale can still be compared to a population-specific cut-off score to enable the categorization into suffering versus not suffering from clinically relevant depressive symptoms. Furthermore, taking into account the existing literature on the courses, consequences, and comorbidities of depressive symptoms, it can be concluded that depressive symptoms vary along a unidimensional spectrum of unipolar depression and do not indicate qualitatively different and disparate categories (Rodríguez et al., 2012; Solomon, Haaga, & Arnow, 2001). Arguably, categorical diagnostics—by applying an all-or-none law—may underestimate the importance of SubD because clinically relevant depressive symptoms may impair a person in important areas of functioning even if the symptoms do not meet MDD criteria (Rodríguez et al., 2012).

Additionally, categorical versus dimensional diagnostics come with differences regarding the item content which may be especially important in old age populations. While diagnostic instruments like the DSM-5 or the ICD-10 are not age-specific, diagnostic scales may include items on co-occurring symptoms (e.g., items on interpersonal relations as in the CES-D; Radloff, 1977); may extend the number of well discriminating items on a given criterion (e.g., include several negative affect items as in the SDS; Shafer, 2006; Zung, 1965), and may leave out others that do not discriminate well in a given population or that tend to confound the diagnosis of depressive symptoms in NH residents (e.g., somatic symptoms as in the GDS; Yesavage et al., 1982).

These differences are especially important in aging research as an age-related response shift on some depression criteria may be expected, which may additionally explain the higher prevalence of MinD and SubD when compared to MDD in older rather than younger adults (Gallo, Anthony, & Muthén, 1994; Göbel, Kipp, & Struwe, 1997). For example, a DSM-5-based diagnosis of a MDD requires the occurrence of either *depressed mood* or *marked diminished interest or pleasure*, while somatic or cognitive complaints are only countable if one of the two core symptoms is present (American Psychiatric Association, 2013). Older adults, though, were less likely than younger adults to endorse dysphoria on one item including the two core symptoms, while being more likely than younger adults to endorse somatic and cognitive symptoms (Alexopoulos, 2005; Gallo et al., 1994). Somatic and cognitive symptoms were even more prominent in NH residents compared to community-dwelling older adults (Ancoli-Israel & Kripke, 1991; Hoffmann et al., 2014). However, these symptoms are not depression-specific and may either contribute to the development of depressive symptoms or be due to physical illness and thus confound the diagnosis of depression (Linden, Borchelt, Barnow, & Geiselmann, 1995; Norris, Arnau, Bramson, & Meagher, 2004). As residents suffering from cognitive disorders were typically not excluded from the epidemiological studies (Meeks et al., 2011), this symptom overlap may have led to counting cognitive symptoms as depressive symptoms and may have contributed to the higher prevalence rates of SubD in NH residents compared to community-dwelling older adults.

Summarizing, dimensional scales provide many advantages, namely the opportunity to also examine depressive symptoms in non-pathologic residents; to estimate the severity of depressive symptoms, and to measure depressive symptoms with age-specific items while to excluding potentially biasing somatic items. Motivated by these advantages, a dimensional depressive symptoms score rather than a clinical depression diagnosis was used in the present dissertation.

1.1.3 Importance of Nursing Home Residents' Depressive Symptoms

In Germany, yearly costs per individual suffering from MDD range between $1345 and $1479 (Luppa, Heinrich, Angermeyer, König, & Riedel-Heller, 2007), which highlights the societal economic burden of depression. For NH residents, depressive symptoms were also related to an increased need of care and an increasing number of hospitalizations per year, which may further increase depressive symptoms-related health care costs (Fries, Mehr, Schneider, Foley, & Burke, 1993; Luo et al., 2015). Besides their impact on the societal and organizational level, depressive symptoms are relevant for the individual resident's coping abilities in everyday life. Depressive symptoms cross-sectionally explain, e.g., rates of impaired basic everyday competence (Verhülsdonk & Engel, 2012), reduced social engagement (Achterberg et al., 2003), and restricted life-space (Mortenson, Miller, Backman, & Oliffe, 2012), for example. Beyond that, residents' depressive symptoms have been found to be a risk factor for ADL degradation and, in the case of MDD, for mortality longitudinally (Bürge, von Gunten, & Berchtold, 2013; Parmelee et al., 1992). Therefore, it appears relevant to better understand the dynamics and associated factors behind NH residents' depressive symptoms, as well as their development and likely promising interventions.

1.2 Toward a Conceptual Model of Depressive Symptoms in the Nursing Home

A range of models are available to explain depressive symptoms (see Table 1.1).

Table 1.1 A Selection of Key Models of Depressive Symptoms

- Biological models including
  - genetic factors, which influence other mechanisms (e.g., Albert & Benkelfat, 2013; Major Depressive Disorder Working Group of the Psychiatric GWAS Consortium, 2013; Power et al., 2017)
  - altered monoamine activity (e.g., Albert & Benkelfat, 2013; Albert, Benkelfat, & Descarries, 2012)
  - altered brain structure and function (e.g., Dietrich & Audiffren, 2011; Mayberg, 1997; Schmaal et al., 2016; Schwichtenberg et al., 2016)
  - altered hypothalamic-pituitary-adrenal (HPA) axis activity (e.g., Belvederi Murri et al., 2014; Pariante & Lightman, 2008)
  - altered neuroimmunological activity (e.g., Eyre, Papps, & Baune, 2013; Walsh et al., 2011)
  - altered neuroplasticity (e.g., Brunoni, Lopes, & Fregni, 2008; Ernst, Olson, Pinel, Lam, & Christie, 2006; Yuan et al., 2015)
  - combinations of those approaches (e.g., Archer, Josefsson, & Lindwall, 2015; Haase & Brown, 2015; Krishnan & Nestler, 2008; Massart, Mongeau, & Lanfumey, 2012; Pittenger & Duman, 2008)
- Behavioral theories including the model of perceived lack of control and learned helplessness (e.g., Miller, Rosellini, & Seligman, 1986)
- Cognitive theories of depression including
  - Beck's (1974) theory of negative cognitive schemata and the cognitive triad
  - Ellis' (1977) theory of irrational beliefs (ABC-model)
- Social theories of depression including the interpersonal approach to depression (Klerman & Weissman, 1986)

  } The integrative theory of depression (Lewinsohn, Hoberman, Teri, & Hautzinger, 1985)
- A phenomenological perspective considering depression as a lack of embodied affectivity (Fuchs & Koch, 2014)
- The tripartite model of depression (Clark & Watson, 1991)
- …

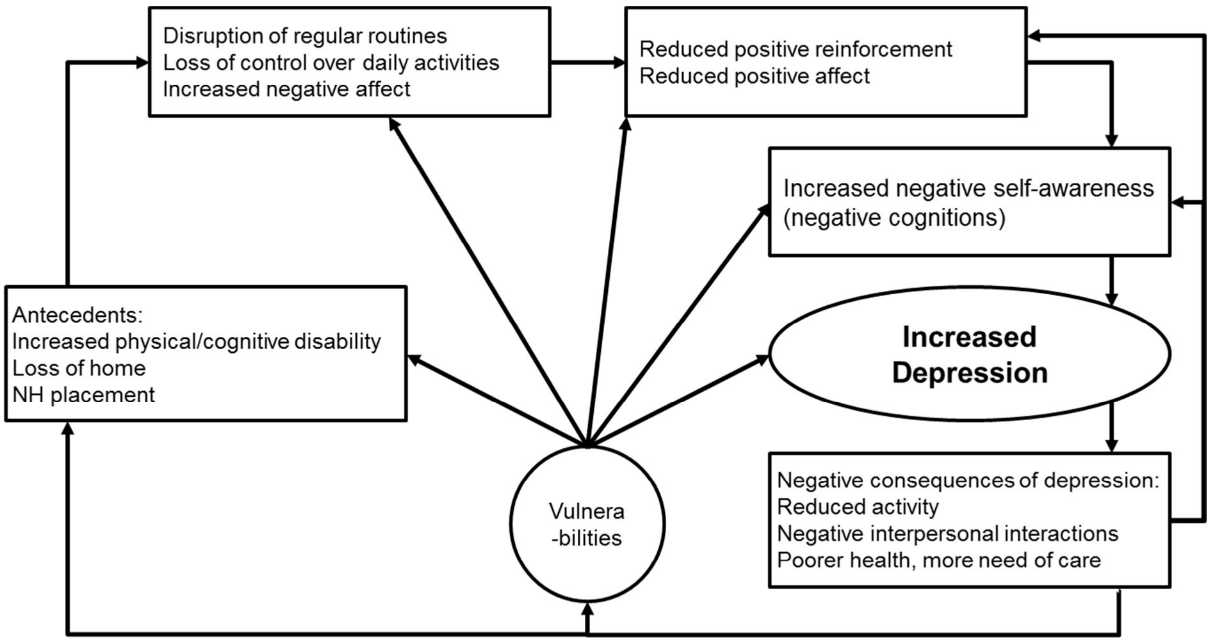
Lewinsohn et al.'s (1985) integrative approach to depression appeared as the most useful background for the present dissertation for three major reasons. First, the model synthesizes many elements of established theories of depression (e.g., cognitive, behavioral, social; see Table 1.1) and thereby proposes a model of superordinate process variables contributing to the development or prevention of depressive symptoms (Lewinsohn et al., 1985). The exact variables within this process, however, can be adjusted according to the particular group under study. For example, Lewinsohn et al.'s (1985) model proposes antecedents of depressive symptoms which may be specified for NH residents as, e.g., increased physical disability (Meeks & Depp, 2003). Meeks and Depp (2003) actually adapted Lewinsohn et al.'s (1985) model to the NH context, which provides the basis for the present dissertation. Furthermore, new variables, which have not previously been named in the context of this model, may be integrated. This option is especially relevant for the present dissertation because theoretical foundations for the associations between residents' social activity, physical activity (PA), or their life-space and depressive symptoms are still lacking. As these are indeed the focus of this thesis, adapted models were developed and will be presented in the following chapters.

Second, the model is empirically founded. Lewinsohn et al. (1985) provide a comprehensive review of the empirical literature to justify each path they propose. Later, Meeks and Depp (2003) draft the model for NH residents and name empirically-based variables particularly relevant for residents. However, they state that their proposal would "roughly illustrate" (p. 133) the model of depression for NH residents, which is why some research gaps are left open despite the existing empirical foundation.

Third, the model has high ecological validity as it continues to serve as a key model of psychotherapy in older persons with dementia and in NH residents (Hautzinger, 2000; Konnert, Dobson, & Stelmach, 2009; Meeks, van Haitsma, Schoenbachler, & Looney, 2015; Teri, Logsdon, Uomoto, & McCurry, 1997; Verkaik et al., 2011). As the present work was conducted in the *natural lab* of two NHs, it was important to employ a model with high ecological validity or utility. Therefore, the behavioral model of depression in the NH (Meeks & Depp, 2003) was used as the theoretical background for this thesis and was supplemented by further theoretical approaches as needed (e.g., Calkins, 2001; Carstensen, Fung, & Charles, 2003; Webber, Porter, & Menec, 2010).

Having provided the reasoning for the model of depression in the NH, it will be introduced shortly. Meeks and Depp (2003) assume depression-evoking events or antecedents to disrupt scripted everyday activities, thereby elevating the rate of aversive experiences and reducing the rate of positive ones, thus increasing negative cognitions, and "initiat[ing] the depressogenic process" (p. 344).

Figure 1.1 A Model of Depressive Symptoms in Nursing Homes



Note. Meeks, S., & Depp, C. A. (2003). Pleasant events-based behavioral intervention for depression in nursing home residents: A conceptual and empirical foundation. *Clinical Gerontologist*, *25*(1-2), 125–148. https://doi.org/10.1300/J018v25n01_07*. Reprinted by permission of Taylor & Francis.

As the dissertation's focus is on depressive symptoms rather than on depression, I will refer to the model as the *model of depressive symptoms* below. Meeks and Depp (2003) adapted the model to explain NH residents' depressive symptoms (Figure 1.1) and, in particular, referred to increased physical disability as an *antecedent* of depressive symptoms (they further suggested cognitive disability, loss of home, and NH placement as potential antecedents). Starting from antecedents, they name *disruption of regular routines, loss of control over daily activities, and increased negative affect* as mediating the effect of disability on increased depressive symptoms. Additionally, they propose *reduced positive reinforcement* and *increased negative self-awareness* as mediators between everyday activities and *increased depressive symptoms*.

Furthermore, an important element of the model is a feedback loop (bottom of Figure 1.1). With this loop, it is proposed that *negative consequences* result from increased depressive symptoms—namely reduced activity, negative interpersonal interactions, poorer health, and more need for care. These, in turn, would further impair the antecedents of depressive symptoms, meaning that a person may get trapped in a downward depressive symptoms spiral.

As moderating factors, the authors include *vulnerabilities* (risk and protective factors) that may have the potential to impact on all process variables leading to depressive symptoms (Lewinsohn et al., 1985; Meeks & Depp, 2003). Lewinsohn et al. (1985) named female sex and certain age ranges as predisposing vulnerabilities for depressive symptoms, which was supported for old age groups as well (Luppa et al., 2012). However, it should be noted that these variables may be proxies for a range of underlying processes including social and psychological factors that include roles, support, live events, or coping capacities.

Finally, an additional shorter and therefore faster feedback loop is modeled from the negative consequences of depressive symptoms back to reduced positive reinforcement and increased negative self-awareness (Figure 1.1). These two variables are the most proximal causes of depressive symptoms in the model (Lewinsohn et al., 1985; Meeks & Depp, 2003). That is, depressive symptoms-related consequences like negative interpersonal interactions may immediately reduce positive reinforcement and thereby provoke the depressive symptoms spiral.

The model thus aims at unifying to some extent several approaches to depressive symptoms, e.g., learned helplessness (Miller et al., 1986) in *loss of control over daily activities / increased negative affect*, cognitive biases (Beck, 1974) in *negative cognitions*, or biochemical predispositions (Krishnan & Nestler, 2008) in *vulnerabilities.* Furthermore, additional constructs relevant to NH residents' depressive symptoms can be embedded into the model, e.g., basic and expanded competence.

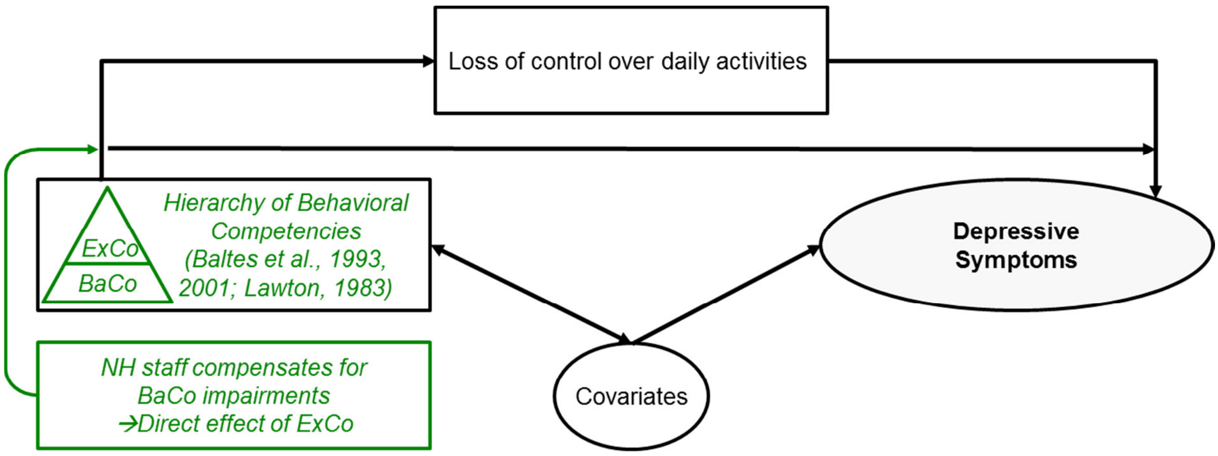
1.3 Important Linkages between Everyday Competence and Depressive Symptoms

As has been argued, NHs are not least special settings regarding residents' depressive symptoms because important antecedents are highly prevalent in NH residents, e.g., functional impairment (Eisses et al., 2004; Kaup et al., 2007; Kojima, 2015), difficulties in communicating with co-residents (Park, 2009; Park et al., 2012), and cognitive impairment (Boorsma et al., 2012; Hoffmann et al., 2014). As outlined above, some of these may also be consequences of depressive symptoms. On the other hand, the central purpose of NHs is to care and compensate for functional impairments of older adults (Sanford et al., 2015). Additionally, they offer a range of activities within the home to ease social participation for residents and to prevent loneliness. Therefore, NHs may simultaneously foster *and* counteract depressive symptoms. However, previous research largely focused on either functional impairment or social engagement; thus, the differential association of both of these important everyday activity components with residents' depressive symptoms remains unclear. Study I addressed this question using a conceptually driven distinction between basic and expanded competence and latent variable modeling as suggested by M. Baltes and colleagues.

M. Baltes et al. (2001; 1993) developed a model of everyday competence that extracted and integrated the essential elements of multiple perspectives on older adults' competence. For example, competence had previously been defined from a skill perspective (e.g., as performance-based skills, Katz, Moskowitz, Jackson, & Jaffe, 1963; or as coping skills, Lazarus & Folkman, 1984), from a mastery perspective (Bandura, 1989), or as resulting from the interaction with the environment (Lawton, 1982) among others (see also Wahl, 1998). Baltes et al. (1993) suggested a unifying theoretical framework and defined *everyday competence* as "the effective management of daily life, requiring the orchestration of skills ranging from those required for personal care to leisure activities and their implementation when needed during the day" (p. 658). Furthermore, they conceptualized competence in a two-dimensional way, differentiating between a basic (BaCo) and an expanded level of competence (ExCo, Baltes et al., 1993; Baltes et al., 2001).

According to this framework, BaCo comprises activities that are routinized, essential for survival, and universally normative (e.g., basic ADL like walking or bathing). In some contrast to BaCo, ExCo comprises activities that primarily stem from individual preferences, that give life meaning beyond basic self-preservation, and are strongly culturally determined (e.g., leisure activities). Conforming to Lawton's (1983b) hierarchy of behavioral competence, Baltes et al. (1993) consider BaCo as being less complex than ExCo and as an essential resource that facilitates ExCo. Thus, they conceptualized BaCo and ExCo as different but related dimensions of everyday competence (see *Hierarchy of Behavioral Competencies* in Figure 1.2).

Figure 1.2 Theoretical Model of Important Linkages between Everyday Competence and Depressive Symptoms



Notes. Model adapted from Meeks and Depp (2003); green italics for additional theories explaining the differential paths from BaCo via perceived control or from ExCo to depressive symptoms.

In a cross-sectional study, based on data of the Berlin Aging Study, Baltes et al. (1993) further tested structural paths between predictors and BaCo and ExCo. They assumed that BaCo, due to its relevance for survival, would be predicted by bio-medical and health-related variables. In contrast, they assumed that ExCo would be predicted by psychological, sociocultural, or economic variables due to its relation to individual preferences and goals (Baltes et al., 1993). Results indeed confirmed differences in BaCo were explained by health-related mobility impairments and depressive symptoms, which they counted among health-related variables (Baltes et al., 1993). The latter finding is especially interesting for the present dissertation because depressive symptoms were an independent, proximal, and significant predictor of older adults' BaCo. However, possible bidirectional or reversed paths have so far not been investigated—neither in community-dwelling older adults nor in NH residents. This would be important because it would advance the understanding of how BaCo in older adults may contribute to or buffer against depressive symptoms and would thereby hint at an interesting way to use BaCo-enhancing interventions as a means of counteracting depressive symptoms developments. Differences in ExCo were, as expected, predominantly explained by personality variables, cognitive variables, and socio-economic status (Baltes et al., 1993).

This model seemed promising to better understand interdependencies between BaCo impairment or ExCo-related activities and NH residents' depressive symptoms as it includes process variables that may advance the understanding of associations between BaCo, ExCo, and depressive symptoms. Study I shows that BaCo impairments may be associated with more depressive symptoms because they may disrupt daily routines and come with feelings of loss of control and helplessness. Study I also shows ExCo-related activities may be associated with fewer depressive symptoms because they provide a chance for gratifying and, thus, reinforcing encounters (e.g., for social contacts, Carstensen et al., 2003). Therefore, the effects of BaCo and ExCo may both be significant, though independent of each other, which was supported in Study I (see Figure 1.2).

In checking the robustness of these findings, home affiliation, demographic variables, and cognitive health were considered as covariates. Study I showed that none of these covariates significantly predicted depressive symptoms cross-sectionally, while the expected effects of BaCo and ExCo remained unchanged when controlling for covariates.

Additionally, Study I examined the model-proposed mediation of perceived control between BaCo and/or ExCo impairment and depressive symptoms cross-sectionally. *Loss of control over daily activities* (see Figure 1.2), may be considered as an unfavorable imbalance between perceived dependency versus perceived control and may be captured well by Rotter's (1966) generalized control expectancy. This generalized perceived control consists of two poles, namely external locus of control (events perceived as out of a person's control) and internal locus of control (events perceived as contingent on a person's action). While the association between perceived control and depressive symptoms is well-known for older adults (Bjørkløf, Engedal, Selbæk, Kouwenhoven, & Helvik, 2013), it was less clear for NH residents already operating in a control-reducing environment. Therefore, Study I also addressed this question cross-sectionally and found support that BaCo's but not ExCo's association with depressive symptoms is mediated by perceived control. That ExCo was not mediated by perceived control cross-sectionally does not exclude the possibility that it is mediated longitudinally. Otherwise, it may well be that NH staff compensates for BaCo impairments, thereby enabling residents to participate in ExCo-related activities besides their possible functional impairments. Thus, ExCo-related activities may directly be associated with reduced depressive symptoms without being mediated by a loss of control (see Figure 1.2).

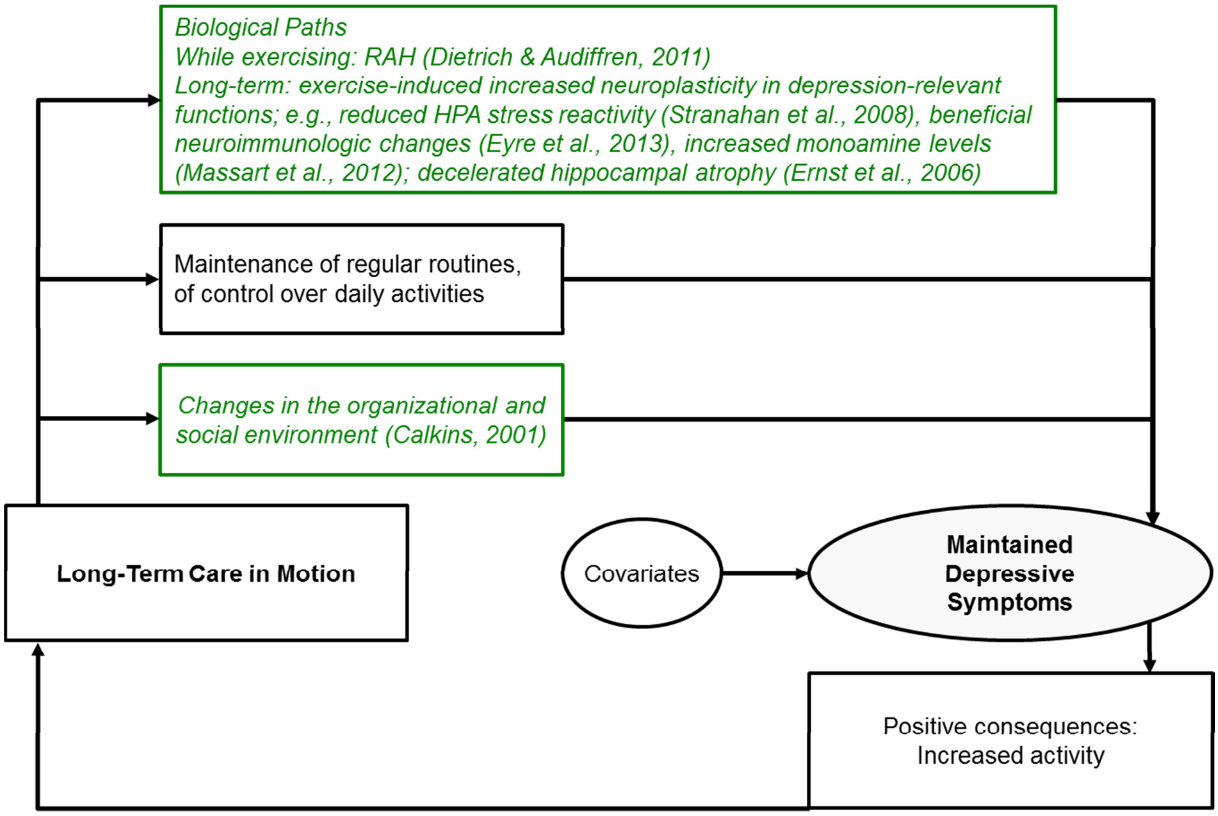
1.4 Effects of a Physical Activity Program on Depressive Symptoms

Having shown the cross-sectional association between BaCo impairments and depressive symptoms in Study I, Study II aimed at investigating in greater detail the role of a PA-enhancing training program on residents' depressive symptoms longitudinally.

The model of depressive symptoms in the NH claims increased physical disability as an antecedent of increased depressive symptoms and reduced activity as a negative consequence of depressive symptoms (Meeks & Depp, 2003). LTCMo aimed primarily at increasing residents' activity behavior sustainably and thereby at improving their overall quality of life including reduction of depressive symptoms (Jansen, Claßen, Hauer, Diegelmann, & Wahl, 2014). Indeed, Wingerath (2016) has shown that LTCMo participants were significantly better at performance-based balance (Standing time in side-by-side, tandem, and semi-tandem stand), lower extremity function (Short Physical Performance Battery), and functional mobility (Timed Up and Go) compared to non-participants after the training. Thus, LTCMo's PA-enhancing training successfully enhanced residents' BaCo. This improvement, in turn, may have helped residents to regain maintenance of control over daily activities (see second path in Figure 1.3), increasing positive reinforcement. The confluence of these factors may finally have resulted in fewer depressive symptoms.

Besides this psychological pathway, the training may have triggered depression-relevant biological systems, e.g., by activating the reticular system (Dietrich & Audiffren, 2011), reducing HPA axis reactivity (Stranahan, Lee, & Mattson, 2008), inducing beneficial neuro-immunological changes (Eyre et al., 2013; see top path in Figure 1.3).

Figure 1.3 Theoretical Model of the Effects of a Physical Activity Program on Depressive Symptoms



Notes. Model adapted from Meeks and Depp (2003); green italics for additional biological and environmental theories explaining the paths from the multi-component LTCMo training to depressive symptoms.

Further, the training may have triggered depression-relevant changes in the organizational and social environment (Calkins, 2001; see third path in Figure 1.3). In particular, the full training program also involved NH activity coordinators who were trained to become PA trainers themselves and who were expected to implement the training sustainably in the NHs. Thereby, organizational routines and values may have changed overall toward more PA support, which again may have helped residents to improve their BaCo and may also have reduced their depressive symptoms. Furthermore, the training fostered social contacts, which may have changed residents' social environment irrespective of physiological or psychological effects (e.g., by becoming friends with co-residents they met in the training; see green box in the center of Figure 1.3), and may thereby have reduced depressive symptoms.

During the study training period and the ongoing staff-led training afterwards, LTCMo may have interrupted the proposed feedback loop of physical impairment, depressive symptoms, and lowered activity. By this means, LTCMo may have helped to decrease depressive symptoms or postpone the expected increase in depressive symptoms at residents' end of life, given that many residents are already in their terminal phase (Gerstorf et al., 2010). However, as a decrease rather than stability in BaCo is expected as well (Gerstorf, Ram, Lindenberger, & Smith, 2013), neither expect a training-related increase in BaCo nor a decrease in depressive symptoms was expected. Rather, we expected a training-related prevention of the expected BaCo decrease and a training-related stabilization of residents' depressive symptoms; therefore, the expected effects were adjusted from *increased* and *decreased* to *maintained* (Figure 1.3). Figure 1.3 displays the proposed psychological, biological, and environmental paths that may mediate between the PA-enhancing training program and residents' depressive symptoms. Empirically, time-dependent training group indicators were used as proxies for the proposed biological, psychological, social, and environmental paths. That is, the difference in depressive symptoms was investigated between training and not training residents immediately after the study training and also after three months of sustained, staff-led training.

Interestingly, despite this theoretical reasoning, several randomized controlled trials (RCTs) on exercise for depressive symptoms in NHs yielded null-results (e.g., Chin A Paw, van Poppel, Twisk, & van Mechelen, 2004; Conradsson, Littbrand, Lindelöf, Gustafson, & Rosendahl, 2010; Rolland et al., 2007; Underwood et al., 2013). These studies, however, had a number of shortcomings such as standardized rather than tailored exercises, inflexible exercise intensity, short training periods, or power-unfriendly data-analytical methods. Study II identified potential shortcomings of previous studies from the theoretical considerations, and showed how LTCMo addressed them. For example, LTCMo tailored exercises according to residents' functional and cognitive abilities, increased exercise intensity with residents' heightened abilities, and empowered staff to continue the training. Furthermore, a data-analytical method was applied that may help to detect small but meaningful intervention effects. Study II then re-investigated the effect of a PA training on residents' depressive symptoms using LTCMo data including the effects of potentially influential risk factors for developing depressive symptoms. The proposed training effects on depressive symptoms emerged as expected and were robust when controlling for covariates including perceived control which was a significant predictor in Study I.

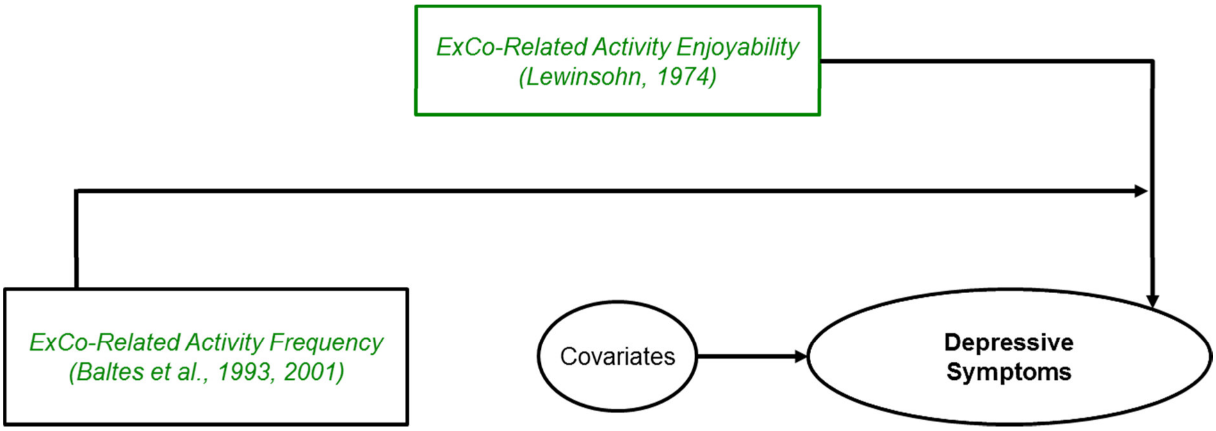
1.5 Linkages between Frequency and Enjoyability of Expanded Everyday Activities and Residents' Depressive Symptoms

Building on Study I results, which showed the significance of both BaCo impairment and ExCo-related activities for residents' depressive symptoms and building on the reasoning behind pleasant events-based interventions for residents' depressive symptoms (e.g., Konnert et al., 2009; Meeks et al., 2015; Travers, 2015; Verkaik et al., 2011), it was surprising to find that previous research had thus far not considered enjoyability besides frequency of specific ExCo-related activities as predictors of residents' depressive symptoms. ExCo-related activities appear as particularly interesting as a means to counteract depressive symptoms, as they are meaningful, modifiable, and strongly related to experiencing fewer depressive symptoms (Meeks et al., 2015; Theurer et al., 2015). Even Lewinsohn (1974) emphasized the differentiation between frequency of activities and their respective enjoyabilities (intensity of gratification). This differentiation was carried over to later process models (Lewinsohn et al., 1985; Meeks & Depp, 2003) in which activity frequency appeared as an antecedent of depressive symptoms (e.g., the frequency of an ExCo-related activity) and activity enjoyability qualified the rate of positive reinforcement gained from activity frequency. That is to say, both frequency and enjoyability determine the rate of positive reinforcement drawn from an activity, thus predicting depressive symptoms better than frequency alone.

Further qualifying the association, Lewinsohn (1974) proposed different activity types (e.g., bodily, cognitive, social) to be differentially associated with depressive symptoms. Previous research supported differential correlations between depressive symptoms and activity frequency or enjoyability (Hsu & Wright, 2014) depending on the type of

ExCo-related activities. Study III provides activity-specific reasons for why effects were or were not expected for self-initiated contact with co-residents or staff and participation in in-home activities. Figure 1.4 shows a sketch of the expected associations.

Figure 1.4 Theoretical Model of Everyday Competence, Enjoyability, and Depressive Symptoms



Notes. Model adapted from Meeks and Depp (2003); green italics for additional concepts explaining paths from activity frequency and enjoyability to depressive symptoms.

Moreover, considering the relevance of BaCo impairment alongside ExCo-related activities for residents' depressive symptoms (Study I) and having provided first evidence of training effects on depressive symptoms (Study II), the training effects were included in Study III analyses. Study III, then, provided first evidence of differential associations between depressive symptoms and the frequency and enjoyability of self-initiated contact with co-residents, contact with staff, and participation in in-home activities. For self-initiated co-resident contact, frequency moderated the effect of enjoyability with fewest depressive symptoms for residents who frequently initiated enjoyable co-resident contact. For self-initiated staff contact, both frequency and enjoyability were only marginally associated with fewer depressive symptoms. And for participation in organized in-home activities, it was enjoyability rather than frequency that predicted fewer depressive symptoms.

1.6 The Role of Depressive Symptoms Regarding Residents' Objectively Measured Life-Space

Study IV changed perspective and considered depressive symptoms as a life-space (LS) predictor rather than as a dependent variable. It focused on residents' sensor-based LS with depressive symptoms being considered as one predictor. The LS construct is introduced first and then its relationship with depressive symptoms is explained.

1.6.1 Importance and Polyvalence of Residents' Life-Space

LS is a polyvalent concept used in biology (habitat or biotope), geopolitics (living space), or social psychology (lebensraum; see Graumann & Kruse, 1995). In behavioral sciences, LS may be defined as "the area through which the subject moved in each 24 hour period" (May, Nayak, & Isaacs, 1985, p. 182). Apparently, this definition concentrates on the spatial extension of LS with the implicit premise that a greater extension would be desirable.

A consideration of the extensive work on *lebensraum* may help to understand the origins of this LS premise. The psychological lebensraum concept includes perception and meaning alongside the physical space in which a person lives and behaves. According to Muchow and Muchow's (1935) classic work, a person's lebensraum comprises the physical environment with its functional opportunities (*space in which a person lives*), the subjective perception of this environment (*space a person experiences*), and an individual's acquaintance with the environment (*space that is lived by a person*). That is, a physically identical LS may be perceived differently by different individuals. These different perceptions may then prompt different behaviors (e.g., a chair in the NH hallway may be perceived as a barrier or as an invitation to sit down and rest). A physically identical locomotion determining the LS extension may likewise be the result of differing motivations (e.g., a person may move to the dining room in order to eat or to chat). Similarly, Lewin (1936) elaborated his field theory and defined the psychological LS as the "totality of facts which determine the behavior of an individual at a certain moment" (p. 12). In his conception, the observable behavior and the physical LS result from the interaction of a person and his/her motivation with the physical and social environment. The person's representation of the environment, rather than the observable environment itself, determines his/her behavior, and thereby his/her observable LS extension. Translating his concept to mathematical terms, Lewin considered a person's lebensraum as the hodological space (from greek ὁδός, path) in which a person moves mentally. He postulated the existence of helping and hindering forces within the hodological space (as perceived by the individual) that would influence a person's movement (i.e., the lived space).

Concerning the LS extension, Webber et al. (2010) presented a framework of LS mobility for older adults together with LS determinants. Webber et al. (2010) follow Stalvey, Owsley, Sloane, and Ball's (1999) definition of LS as "the magnitude or extent of travel into the environment, regardless of how one gets there" (p. 472). This definition is especially suitable in the NH where staff can, to a certain extent, compensate for residents' impairments and move them to areas in the NH that they would not reach by themselves. Webber et al. (2010) model seven zones of increasing distance from one's own room with increasing requirements for independent mobility. According to the framework, the mobility to reach each zone is determined by cognitive, psychosocial, physical, environmental, and financial factors. With increasing distance from one's own room, the number of determining factors and their interrelations also increase. Additionally, sex, culture, and personal life history are assumed to influence the five determinants, and thus to influence residents' LS indirectly.

Muchow and Muchow's (1935) as well as Lewin's (1936) conceptions may exemplify how complex the operationalization of a psychological lebensraum is. However, the elusive lebensraum and the observable LS extension are intertwined. A person's lebensraum is determined by the interplay between the physical and social environment and a person's psychological perception and evaluation of these features. This lebensraum, then, determines the observable LS extension. The other way around, the observable LS offers objects (including persons) that may be perceived as motivating forces and that may influence a person's behavior, e.g., by helping fulfill a person's needs. Therefore, a person's LS may also determine psychological lebensraum. The greater a person's LS, the greater the number of potential lebensraum-relevant objects, thus a greater chance to live that space, which may support the premise that a larger LS extension is desirable.

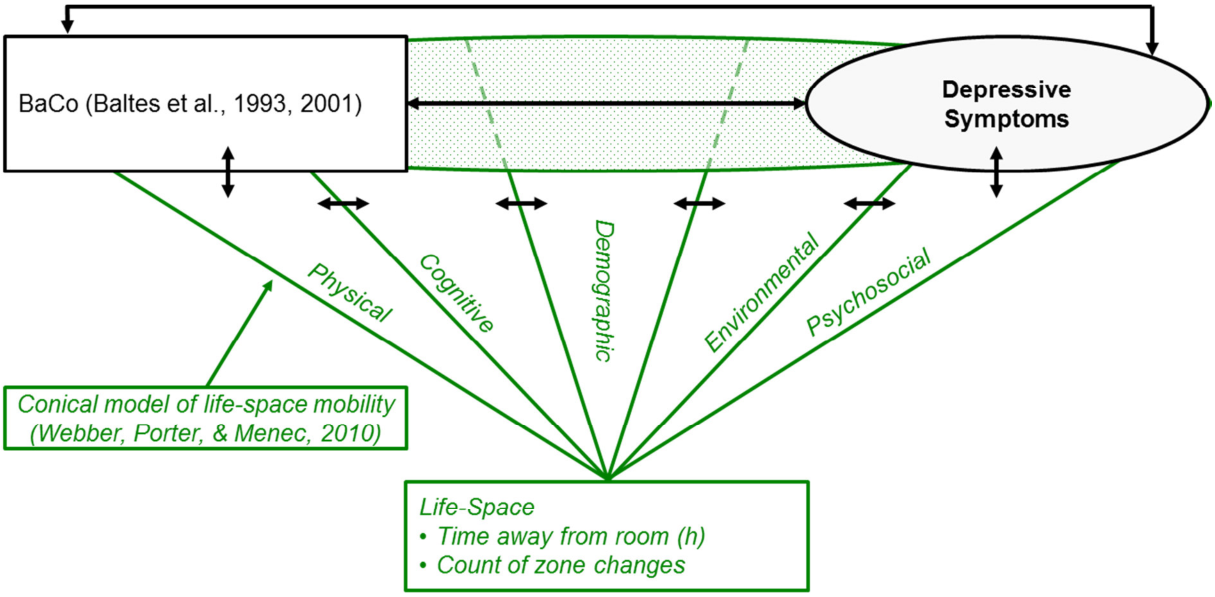
Concerning operationalizations, a person's lebensraum appears to be barely accessible as it relies on unobservable and likely unconscious processes like perception and evaluation of one's environment (Lewin, 1936). The measurement of these inner processes is especially difficult in a sample of NH residents, many of whom suffer from cognitive impairment (Hoffmann et al., 2014). However, operationalizing a resident's manifestation of these inner processes—i.e., measuring a resident's LS extension—appears as more feasible. Using objective, sensor-based measurements would allow an automated, very precise, reliable, and ecologically valid tracking of residents' spatiotemporal whereabouts within the NH. Residents' cognitive impairment, which might be of concern in self-report data, would not influence the sensor-based LS acquisition. Additionally, it would be less time-consuming than behavioral observations and would, therefore, allow for gathering of information on a large number of residents. Bridging the LS extension to the psychological lebensraum in terms of the lived space would be possible to some extent, e.g., by considering mobility, cognition, or depressive symptoms as potential LS determinants.

1.6.2 Relationship between Residents' Depressive Symptoms and Life-Space

Although LS appears currently as a hot topic in research on older adults, with many questionnaire-based approaches having been developed (e.g., Life-Space Assessment, Baker, Bodner, & Allman, 2003; Life-Space Diary, May et al., 1985; Life-Space Questionnaire, Stalvey et al., 1999; Nursing Home Life-Space Diameter, Tinetti & Ginter, 1990), little is known about NH residents' LS—especially regarding their objective measurements. Moreover, the available studies on residents' LS that used behavior mapping based on systematic observational procedures—as a more objective measurement than self-reports—did not focus on the relationship between LS and depressive symptoms (Baltes, Honn, Barton, Orzech, & Lago, 1983; den Ouden et al., 2015; Ice, 2002; Milke, Beck, Danes, & Leask, 2009).

The model of depressive symptoms in the NH proposes reduced activity and negative interpersonal interactions as consequences of depressive symptoms (Meeks & Depp, 2003). These negative consequences of depressive symptoms may be reflected in reduced LS extension, namely in more time spent in the resident's own room, as this is the place to withdraw from activities and interaction partners. This lowered LS extension may again indicate reduced possibilities of having social contact and of participating in in-home activities. As Study I showed, those residents participating less in social and in-home activities than other residents suffered from more depressive symptoms. Therefore, a self-perpetuating circle is expected from increased depressive symptoms via reduced activity and reduced social contact to reduced LS and back to further increased depressive symptoms. As Study IV is a cross-sectional study, it cannot investigate these intra-individual chains, but it can answer the question of how different constructs are related inter-individually and how these inter-related factors predict residents' LS at a given moment in time. For depressive symptoms, an association is expected with a restricted LS indicated by more time spent in the resident's own room.

Figure 1.5 Theoretical Model of Depressive Symptoms as Life-Space Determinant



Notes. Model adapted from Meeks and Depp (2003); LS-determinants as proposed by the model of LS mobility (Webber et al., 2010) marked in green italics.

With respect to the model of LS-mobility as suggested by Webber et al. (2010), depressive symptoms may be a psychosocial LS-determinant; BaCo-related gait speed may be a physical LS-determinant, and vulnerabilities (e.g., cognitive impairment, living on dementia-care unit, or sex) may be cognitive and demographic LS-determinants. Institutionally determined daily routines may be considered an additional vulnerability for depressive symptoms as they restrict residents' room to maneuver, thus limiting their control over daily activities (see Figure 1.5). Institutionally determined routines may also be an environmental LS-determinant (see Figure 1.5). Besides, financial LS-determinants (Webber et al., 2010) appear to be mostly irrelevant in the NH and are, therefore, excluded from Figure 1.5.

In previous empirical literature, the self-report-based Nursing Home Life-Space Diameter, which divides LS into four zones of different distance to a resident's own room, was used to investigate NH residents' LS. Using this instrument, inconsistent findings have been reported for the association between depressive symptoms and residents' LS (Mortenson et al., 2012, 2011). As these two analyses appear to be based on the same sample and data, the different analytical approaches may have caused the differing results and might be relevant for Study IV analyses. For example, Mortenson et al. (2012) used fewer predictors than Mortenson et al. (2011), they imputed missing data and used an ML-based analysis technique. This implies that it is essential to theoretically deduce a limited number of LS predictors and to use a state-of-the-art data-analytical technique accounts for with missing data to avoid estimation biases.

1.7 Open Research Questions and Contribution of the Present Dissertation

To summarize, the identified research gaps can be grouped around four topics: predictors of depressive symptoms, development and malleability of depressive symptoms, factors associated with the depressive symptoms development, and depressive symptoms as LS predictor. The following Table 1.2 delineates the contributions of the present dissertation to fill these gaps by listing the research questions and associated hypotheses tested in Studies I–IV. The presented hypotheses will be picked up on in the discussion in Chapter 7.

Table 1.2 Research Questions Addressed

Topic	Research Questions	Hypotheses		Study
Predictors of Depressive Symptoms	What are the basic associations between BaCo, ExCo and depressive symptoms?	Ia)	BaCo and ExCo both reveal strong relations with NH residents' depressive symptoms.	I
	Which role does perceived control play in the association between BaCo, ExCo, and depressive symptoms?	Ib)	Perceived control mediates between NH residents' BaCo as well as ExCo and their depressive symptoms cross-sectionally.	
Development and Malleability of Depressive Symptoms	How do depressive symptoms develop across nine months in the NH?	IIa)	Depressive symptoms increase across time-in-study as implied by terminal decline literature for residents not participating in the PA intervention.	II
	How does the depressive symptoms development differ for training versus non-training residents?	IIb)	Residents who participated in the PA intervention have fewer depressive symptoms compared to residents who did not participate both immediately post as well as three months after completion of the PA intervention.	
Factors Associated With the Depressive Symptoms Development	How do ExCo-related activities and their enjoyabilities predict residents' depressive symptoms? How do the associations vary for different ExCo-related activity domains?	IIIa)	For self-initiated co-resident contact, contact frequency moderates the effect of enjoyability. Residents having frequent and enjoyable co-resident contacts show the fewest depressive symptoms.	III
		IIIb)	and IIIc) For staff contact and participation in organized in-home activities, enjoyability rather than frequency predicts fewer depressive symptoms.	
Depressive Symptoms as Life-Space Predictor	How do depressive symptoms impact on residents' LS cross-sectionally?	IV)	Increased depressive symptoms are associated with restricted LS.	IV

Addressing predictors of depressive symptoms, Study I used a latent variable modeling framework to investigate the role of BaCo and ExCo as well as the cross-sectionally mediating role of perceived control. To test the robustness of the findings, a simulation study examined the power and potential estimation biases accounting for our sample size and missing data patterns. Additionally, covariates were included in the model to further test the robustness of the associations.

Study II then addressed the development of depressive symptoms and the malleability of this development by implementing a BaCo-related physical activity training (LTCMo). This study also suggests a way of dealing with non-normal outcome distributions (namely the gamma distribution for the depressive symptoms score) and a way of testing intervention effects directly given LTCMo's complex study design.

Focusing on factors associated with depressive symptoms development, Study III looked at the ExCo-related activities used in Study I differentially and includes the role of activity enjoyability in association with the development of depressive symptoms.

Finally, Study IV describes a newly developed method of tracking residents' in-home behavior using automated sensors. It describes residents' LS across the day and considers depressive symptoms as LS predictor.

The following Chapter 2 introduces LTCMo, which the data for all cross-sectional and longitudinal analyses were drawn from and reports psychometric properties of the depressive symptoms outcome. Then, Studies I to IV are presented, before all study findings are integrated and discussed in Chapter 7.

2

Methods

2.1 Setting

The present work is based on data from Long-Term Care in Motion (LTCMo; Current Controlled Trials ISRCTN96090441; Jansen et al., 2014). LTCMo is part of EU's *Social Innovations Promoting Active and Healthy Aging* [HEALTH.2012.3.2-3] and was headed by Prof. Dr. Hans-Werner Wahl and Prof. Dr. Klaus Hauer. LTCMo set up a previously established and RCT-proven PA intervention (Hauer et al., 2001; Hauer et al., 2012; Schwenk et al., 2014) and adjusted it to NH residents' needs. First, the study aimed at promoting residents' PA behavior. Second, LTCMo strived to promote healthy aging of NH residents at large, which includes possible consequences in terms of reducing residents' depressive symptoms.

The intervention took place in two NHs in Heidelberg. Both homes were located in the same neighborhood and run by the same organization (AGAPLESION); they offered equally high care standards, employed activity coordinating staff who offered similar activity programs, and provided a dementia-care unit, a restaurant or café, and a chapel on-site.

Importantly, the intervention was offered to *all* residents willing to participate, including residents with behavioral disturbances or severe functional or cognitive impairment who were typically excluded in previous intervention work in the NH setting (e.g., Chin A Paw et al., 2004; Tse, Tang, Wan, & Vong, 2014; Vankova et al., 2014). Hence, all non-palliative long-term care residents were approached and they (or their legal representative) provided written informed consent. Ethical approval for the project was obtained from the Ethic Review Board of the Faculty of Behavioral and Cultural Studies at Heidelberg University (approval letter from December 19, 2012; no code provided). The study conformed to the policy and mandates of the Declaration of Helsinki.

2.2 Design

A longitudinal pre-post intervention and control / waiting group design was applied to track residents' development and to assess intervention effects. All participants—whether in the active intervention group or not—were assessed before (Pretest), after (Posttest), and following the intervention (Follow-Up), occurring at three-month intervals. Additionally, a baseline assessment was conducted three months before the pre-intervention measurement in NH 2 to investigate residents' development under care as usual. Thus, residents from NH 2 provided information at four measurement occasions. The time schedule of the data collection and the intervention is shown in Table 2.1.

Table 2.1 Time Table of Data Collection and Intervention

Month	NH 1	NH 2
2014 May	Pretest	
2014 June	12-Week Intervention	
2014 July		
2014 August		
2014 September	Posttest	
2014 October	12-Week Continued Intervention by Staff	Baseline
2014 November		
2014 December	Follow-Up	
2015 January		
2015 February		Pretest
2015 March		12-Week Intervention
2015 April		
2015 May		
2015 June		Posttest
2015 July		12-Week Continued Intervention by Staff
2015 August		
2015 September		Follow-Up

The homes hosted 99 and 160 long-term care residents at study start, respectively. Of those, 182 (70%) provided written informed consent before the first measurement occasion. At all occasions, non-participating residents could enter the study, though only residents participating in the pretest could also join the training groups. The flow of participants is displayed in Figure 4.1 (Study II).

2.3 Short Description of the Physical Activity Training

A PA-enhancing training, which had proven effective in RCTs studying geriatric patients with dementia (Hauer et al., 2012), was adapted to the needs and resources of NH residents. The training followed a *system approach* including contacting the NH directors; evaluating pre-existing PA courses; training care staff in PA-supportive communication techniques to be used in everyday care contacts, and supporting activity-coordinating staff in implementing PA courses sustainably (except serious games) after completion of the 12-week study intervention. Furthermore, the resident-oriented intervention aimed at changing residents' PA *behavior* rather than solely at improving their BaCos. To achieve this goal, LTCMo offered *different training components* (i.e., group or individual training, and/or serious games) for specific subgroups, which residents could freely choose to join according to their wishes, their functional status, and their living unit. Residents could also participate in several training components. The training utilized dementia-associated communication strategies and techniques to handle behavioral challenges especially in the closed wards. As residents benefit most from individually-tailored and intense exercises (Fiatarone Singh, 2002), groups were composed of residents who were homogeneous regarding their functional status and trained using group-tailored exercises of increasing intensity.

Table 4.1 (Study II) displays the intervention components as well as inclusion criteria for the exercise groups; Table 4.2 (Study II) displays descriptive data of the sample by intervention group. Apparently, residents in the actively training group (PA-IG) compared to the not actively training (thus naturally occurring control group, Nat-CG), perceived their vision as better ($p < .05$). No other differences between the PA-IG and the Nat-CG were observed. For more detailed information on the resident- and staff-oriented components, please see the LTCMo guidebook (Jansen et al., 2015).

2.4 Procedure and Sample

At every measurement occasion, residents were assessed using an extensive data protocol. That is, they were interviewed by research assistants, proxy-rated by activity-coordinating NH staff, performance-tested for ambulatory residents' functional status, sensor-measured with respect to their PA using accelerometers and regarding their LS using tracking devices. Finally, their demographic and health-related data were taken from the care documentation. Thus, a comprehensive picture of each resident was generated, regardless of potential sensory, cognitive, or functional impairments.

To enhance assessment reliability for interview data at the data-generational level, research assistants were trained in interview techniques with NH residents, especially in dealing with cognitively impaired individuals' potential answering behavior. The training further included talking through potential pitfalls in the questionnaire, providing case examples, and conducting a training role play. To further enhance assessment reliability in case of any doubt regarding understanding of the question, assistants rephrased the question using a standardized alternative formulation printed on the interview sheet. If they still doubted that the resident did not understand the question, they coded the answer as missing. In case of any doubt regarding the answer to a question, assistants repeated the interviewee's answer including the question (e.g., "So you feel happy most of the time?") and had the interviewee validate his or her answer. Before starting the research interviews on their own, assistants received two field supervisions from experienced interviewers, including extensive feedback on interview techniques. This procedure may have helped in discarding invalid answers from the data while maintaining valid answers from all residents, including cognitively impaired ones. In order to test rater-specific differences (rater bias) on interview variables that were treated as interval-scaled (depressive symptoms, internal and external control, perceived vision), post hoc MANOVAs were run using Study I data. The differences were considered by living unit (dementia care vs. other) and were all non-significant ($F(12, 33) = 0.69$, $p > .05$ for residents living on a dementia care unit and $F(36, 308) = 1.28$, $p > .05$ for residents not living on a dementia care unit, respectively). This finding suggests that no significant rater bias is present in our interview data. For a discussion of the psychometric quality of interview data in cognitively impaired residents, see Chapter 7.2.

However, not all measurements were applicable for every resident, resulting in differing sample sizes for the different data generation modes. For example, residents too impaired to be interviewed or who refused to be interviewed did not provide interview data; residents unable to stand did not provide performance-based data; and residents feeling disturbed by the sensors or displacing them did not provide sensor-based data. For more information on study design and measurements, please see the Studies' methods sections and the study protocol (Jansen et al., 2014).

Table A2, Table A3, and Table A4 (Appendix) show descriptive information on study variables by NH site, death-related dropout, and measurement occasion including bootstrap step-down-corrected *p* values from *t*-tests for continuous and Fisher's exact tests for dichotomous variables. Apparently, a higher portion of residents from NH 1 compared to NH 2 lived in the dementia-care unit and they were rated as participating more often in in-home activities (both $p < .01$). No other site-specific differences were observed based on the variables considered. Similarly, no differences were observed between residents dying before follow-up and residents not dying before follow-up. Across time, only the planned empty cells (no values for NH 1 residents at baseline; no values for death-related drop-outs at follow-up) caused differences in comparison to the pretest. For detailed information on study samples, please see the studies' sample descriptions in the following Chapters 3–6 (Studies I–IV).

The LTCMo-related descriptions may have shown the potential of using this data to investigate depressive symptoms in a sample of NH residents and their cross-sectional associations with social activity, functional ability, or life-space as measured by diverse methods (e.g., performance-based test, proxy rating, sensor-based tracking). Additionally, the training data were highly suited to examining the effect of a systematic increase in PA on residents' depressive symptoms. In doing so, this dissertation exceeds LTCMo's goal of investigating training effects on physical activity and functional ability (see Jansen et al., in preparation; Wingerath, 2016).

2.5 Methodological Considerations: Measurement Properties and Reasoning for the 12-Item Geriatric Depression Scale—Residential

The introduction of the prevalence estimations from categorical versus dimensional diagnostics emphasized the importance of carefully choosing an instrument for NH residents that excludes somatic and cognitive symptoms and includes a variety of age-relevant mood items to reliably measure depressive symptoms (Chapter 1.1.2). It appeared useful to choose a dimensional instrument to avoid information loss due to categorization and to be able to extend the research to residents with more or fewer—rather than pathological versus non-pathological—depressive symptoms. Furthermore, to obtain the necessary information from resident interviews without having to consult a clinician, a rater-administered rather than a proxy-rated scale was chosen (for a discussion of [dis-]advantages of self-rating scales see Möller, 2009). That is, the present work focuses on residents' subjective evaluation of their depressive symptoms rather than on a clinician-rated evaluation.[3] The GDS complies with all these demands. It was specifically developed to measure depressive symptoms in geriatric samples. The GDS offers several advantages compared to other depressive symptoms scales. For example, it includes items on *geriatric* depressive symptoms; it excludes somatic items which might bias a depressive symptoms rating in a population largely suffering from multiple diseases (Yesavage et al., 1982), and it was validated in older adults including German NH residents and persons with mild-to-moderate cognitive impairment (Allgaier, Kramer, Mergl, Fejtkova, & Hegerl, 2011; Conradsson et al., 2013; for a discussion of its psychometric quality in cognitively impaired residents in the present sample, see Chapter 7.2).

Several GDS versions are available with the number of items ranging from 4 to 30 (Broekman et al., 2011; D'Ath, Katona, Mullan, Evans, & Katona, 1994; Hoyl et al., 1999; Jongenelis et al., 2007; Sutcliffe et al., 2000; Tang, Wong, Chiu, Lum, & Ungvari, 2005; Yesavage et al., 1982; Yesavage & Sheikh, 1986). Two versions have been developed specifically for NH residents (Jongenelis et al., 2007; Sutcliffe et al., 2000). In the present sample, I strived to choose the version that optimized the trade-off between feasibility, validity, and reliability.

For reasons of feasibility, residents were interviewed using the GDS-15 rather than a longer version (Bach, Nikolaus, Oster, & Schlierf, 1995; O'Neill, Rice, Blake, Walsh, & Coakley, 1992; Yesavage & Sheikh, 1986). To enhance the scale's validity, the GDS versions for NH residents were considered. Sutcliffe et al. (2000), for example, excluded the items "Do you prefer to stay at home, rather than going out and doing new things?" (GDS_9), "Do you feel you have more problems with memory than most?" (GDS_{10}), and "Do you think that most people are better off than you are?" (GDS_{15}) as residents perceived them as "irrelevant or ambiguous" (p. 176).

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[3] Unfortunately, supplementary proxy ratings of depressive symptoms done by NH staff were not feasible in the present study (see Chapter 7.3.2) so that the GDS-12R appeared as the best possible solution.

To decide which of the two NH versions showed better measurement qualities, I investigated these and compared them with the commonly used GDS-15 using latent variable modeling with categorical outcomes, which is formally equivalent to item response theory (IRT) techniques, on Study I sample (first measurements of residents recruited in 2014). IRT allows modelling depressive symptoms as a latent factor ξ from dichotomous GDS items GDS_i. Furthermore, it provides item and scale information functions which index an item's or the test's precision across the range of ξ, rather than giving a single and thus simplified reliability index like Cronbach's α. A useful test offers much information across a broad band of ξ with the maximum at the level of ξ that corresponds to the scale's cut-off point.

The information function $I(GDS_i \mid \xi)$ measures the uncertainty of a *yes* response ($GDS_i = 1$) to a GDS item given a depressive symptoms true score ξ. It equals the ξ-conditioned variance of an item GDS_i multiplied by the squared item discrimination α_i^2. U symbolizing a subject, the following equation holds:

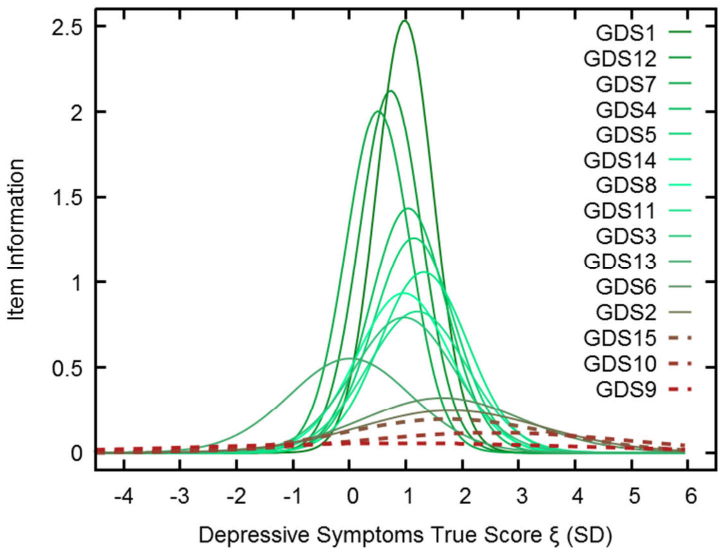
$$I(GDS_i \mid \xi) = \alpha_i^2 \cdot \mathrm{Var}(GDS_i \mid \xi) = \alpha_i^2 \cdot P(GDS_i = 1 \mid U) \cdot P(GDS_i = 0 \mid U). \qquad (2.1)$$

That is, the better an item discriminates between the true scores of persons exhibiting different depressive symptoms, the steeper the information curve, and the higher the maximum information that the item provides about the true depressive symptoms score, given a fixed conditional variance. Also, the more difficult an item is—i.e., the higher the threshold to agree to suffer from the symptom thus the higher $P(GDS_i = 0|U)$—, the more the item information curve will be shifted toward higher depressive symptoms true scores and the higher the maximum conditional variance will be. In combination, item discrimination and difficulty determine the information that a GDS item provides, *given* a specific value of the depressive symptoms true score ξ. Figure 2.1 displays the item information curves for all GDS-15 items[4]. Items in the key are arranged according to their maximum information. The three items providing the least information throughout the depressive symptoms range (indicated by dashed brown lines) are the three items excluded in the GDS-12R. The GDS-8 would additionally

[4] The analyses were run using WLSMV estimations with the delta parameterization as were the analyses for Study I. These parameters can be transformed into IRT parameters (Muthén & Muthén, 2013).

exclude GDS_2, GDS_6, GDS_{12}, and GDS_{13}. Though GDS_2, GDS_6, and GDS_{13} contribute relatively little information, GDS_{12} ("Do you feel pretty worthless the way you are now?") provides the second-most information in the present sample. Additionally, GDS_{13} ("Do you feel full of energy?") provides maximum information on the average depressive symptoms level ($\xi = 0$), that is, it provides information at a lower true score of depressive symptoms than all other items and therefore its exclusion would limit the test's precision around the average level of ξ.

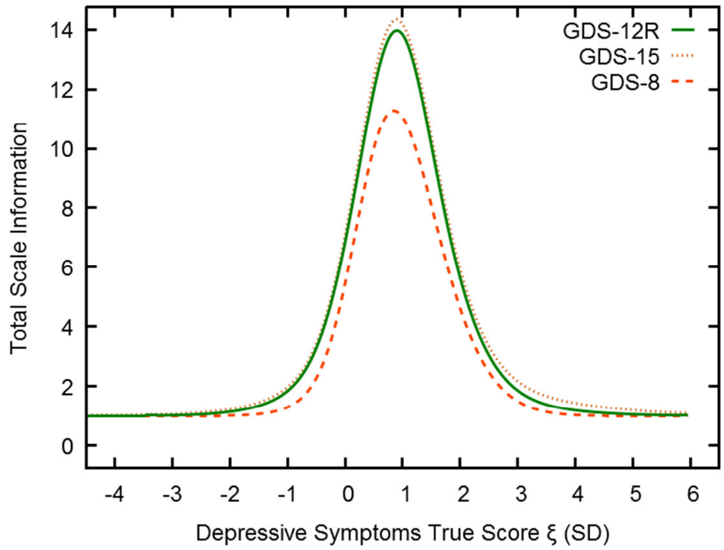
Figure 2.1 Item Information Curves for GDS-15 Items



Note. GDS-12R items in the key ordered by their maximum item information.

Next, I examined the total scale information curves to further investigate the information loss between the GDS-15 and the abbreviated NH versions. A scale's total information curve is the sum of all item information curves. Thus, it indicates how much information all items taken together—i.e., the scale—provide across the depressive symptoms true score range. Figure 2.2 displays these total information curves for the three GDS versions under consideration. The curves for the GDS-15 and the GDS-12R are almost identical, while the curve for the GDS-8 is lower. Additionally, the scales do not differ in the point of maximum information (0.9 *SD* above average ξ).

Figure 2.2 Total Scale Information Curves for GDS Nursing Home Versions



Finally, I considered the scale reliability for binary measures as a simplified measure (Raykov, Dimitrov, & Asparouhov, 2010). The reliability according to this measure was highest for the GDS-12R ($\hat{\rho}_{GDS\text{-}12R} = .84$) and the GDS-15 ($\hat{\rho}_{GDS\text{-}15} = .83$), while it was significantly lower for the GDS-8 ($\hat{\rho}_{GDS\text{-}8} = .81$; $\Delta\rho_{GDS\text{-}12R\text{ - }GDS8} = .04$, $p < .05$).

In conclusion, the GDS NH versions excluded potentially ambiguous items, which seemed to enhance the GDS's validity in the present sample. Regarding information curves from IRT-equivalent analyses and the reliability for binary measures, the GDS-12R did not attenuate the GDS-15's reliability, while the GDS-8 showed some loss of information and reliability compared to the other GDS versions. Therefore, all analyses will be conducted using the GDS-12R.

Further data-analytic considerations on the GDS-12R's distribution and on missing data handling in general can be found in the Appendix. Challenges of dealing with the complex study design; of operating in the NH context, and of interviewing cognitively impaired residents are also addressed in the following studies as well as in the discussion (Chapter 7). Together with my supervisors and coauthors, I strived to find the optimal solution to answer the presented research questions given the LTCMo design and data. The resulting Studies I–IV are presented next and will be discussed in Chapter 7.

3

Study I: A New Look at Nursing Home Residents’ Depressive Symptoms: The Role of Basic Versus Expanded Everyday Competence

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Abstract

Background. Depressive symptoms are highly prevalent in nursing home (NH) residents. The relationship between depressive symptoms and everyday competence in terms of basic (BaCo) and expanded everyday competence (ExCo; see M. Baltes et al., 2001) in the NH setting is however not clear. Applying Lewinsohn's depression model, we examined how residents' BaCo and ExCo relate to their depressive symptoms. Furthermore, we investigated the mediating role of perceived control.

Method. Cross-sectional data from 196 residents (M_{age} = 83.7 years, *SD* = 9.4 years) of two German NHs was analyzed. Study variables were assessed by the Geriatric Depression Scale-Residential (GDS-12R), maximal gait speed (BaCo), proxy ratings of residents' in-home activity participation and self-initiated social contact done by staff (ExCo). Structural equation modeling (SEM) was used and a simulation study was included to determine power and potential estimation bias.

Results. At the descriptive level, one quarter of the residents showed symptoms of depression according to the GDS-12R cut-off criterion. Residents' BaCo and ExCo were independently and equally strongly associated with their depressive symptoms in the SEM analysis. These findings were affected neither by cognitive impairment, sex, nor age. Perceived control mediated between BaCo but not ExCo and depressive symptoms.

Conclusion. Future research needs to follow the connection between residents' everyday competence and their depressive symptoms longitudinally to better understand the underlying mechanisms.

Keywords: Nursing Home, Depressive Symptoms, Everyday Competence, Functional Impairment, Social Activity, Structural Equation Modeling

Introduction

Even though home care remains the predominant care setting for older adults (Gasior et al., 2012), the absolute number of dependent older persons receiving institutionalized care will remain high or even increase in the Western world (European Commission & Economic Policy Committee, 2012). Among nursing home (NH) residents, depressive symptoms are highly prevalent with estimates of up to 45% (Hyer et al., 2005). Furthermore, depressive symptoms are associated with cognitive decline, subjective health problems, impaired activities of daily living (ADL), increased need of care, and mortality (Blazer, 2003; Fries et al., 1993). In ecological terms, the NH context may be considered a special setting concerning residents' depressive symptoms as it may foster *and* counteract depressive symptoms. For example, functional impairment may restrict residents' activity, thus foster depressive symptoms, whereas the numerous group activities offered may facilitate residents' activity, thus counteract depressive symptoms.

To conceptualize depressive symptoms and bridges to activity, Lewinsohn, Hoberman, Teri, and Hautzinger's (1985) now classic approach to depression provides a useful background. Briefly, the authors assume depression-evoking events disrupt everyday activities, thereby elevating the rate of aversive experiences and reducing the rate of positive experiences, thus increasing negative cognitions, and "initiat[ing] the depressogenic process" (p. 344). Meeks and Depp (2003) adapted the model to explain NH residents' depression and particularly refer to physical disability as a potentially depression-evoking event. Therefore, this cross-sectional study aims to emphasize the role of everyday competence regarding depressive symptoms in the NH. Furthermore, this study aims to examine the potentially mediating role of perceived control between residents' everyday activity and their depressive symptoms.

The Role of Basic and Expanded Everyday Competence Regarding Residents' Depressive Symptoms

The everyday competence model by M. Baltes and colleagues (2001) differentiates between BaCo and ExCo to better understand daily autonomous activities. We argue that this model is promising to better understand interdependencies between everyday activity impairment and depressive symptoms. BaCo comprises activities that are routinized, essential for survival, and universally normative (e.g., basic ADL like walking or bathing). BaCo impairments may restrict independent daily activities, hence disrupt daily routines and elevate the rate of aversive experiences due to its immediate dependency-provoking character. Consistent with this assumption, empirical data support the relationship between functional impairment and residents' depressive symptoms (Kaup et al., 2007; Parmelee, Lawton, & Katz, 1989). Therefore, the connection of BaCo impairment with depressive symptoms may be expected substantial and of considerable magnitude in the NH ecology.

In some contrast to BaCo, ExCo comprises activities that primarily stem from individual preferences, give life meaning beyond basic self-preservation, and are strongly culturally determined (e.g., leisure activities). An important component of ExCo is social activity. Considering Lewinsohn et al.'s (1985) model of depressive symptoms, social activity as a potentially reinforcing event can be expected to correlate with fewer depressive symptoms, whereas reduced social activity as a reinforcement-undermining event should correlate with higher depressive symptoms. Indeed, a perceived loss of activity participation, or perceived friendliness of staff and cohabitants was associated with residents' depressive symptoms (Mortenson et al., 2012; Park, 2009). Therefore, the connection of ExCo—and particularly its social activity element—with residents' depressive symptoms may also be expected to be substantial.

Based on conceptual and empirical reasoning, the respective relationships of BaCo and ExCo with residents' depressive symptoms may be qualified in at least two ways. First, BaCo's may exceed ExCo's impact on residents' depressive symptoms. Several models imply a multi-layer hierarchy of behavioral competencies (Baltes et al., 2001; Lawton, 1983b), with BaCo being less complex than ExCo but playing the more fundamental role. Impairments in previously available BaCo may directly and severely disrupt daily routines, coming with dependencies and a lowered rate of positive reinforcement, which may heighten depressive symptoms (Lewinsohn et al., 1985; Meeks & Depp, 2003). Moreover, the more impaired BaCo is, the less complex ExCo-related activities can be conducted. Furthermore, in terms of time budgeting, the more time basic daily activities consume, the less time remains for ExCo-related activities (Baltes et al., 2001).

Second, ExCo's may surpass BaCo's impact on residents' depressive symptoms because greater ExCo (but not so much BaCo) expands the range of potentially reinforcing activities. For example, having social contacts in the NH context should be of greater reinforcing value than walking around. ExCo may be more important predicting depressive symptoms in the NH as compared to the community context, as NHs offer a range of services to compensate for functional impairment. Consequently, enhancing ExCo-related activities may counteract residents' depressive symptoms (Meeks et al., 2015). Besides, the socioemotional selectivity theory claims that emotionally meaningful social goals become more relevant as the individual's future time perspective shrinks (Carstensen et al., 2003). Therefore, potentially reinforcing social activities could be especially important for NH residents who generally represent a very vulnerable subpopulation of old-age individuals (Kelly et al., 2010). In conclusion, we state the hypothesis 1: BaCo and ExCo both reveal strong relations with NH residents' depressive symptoms.

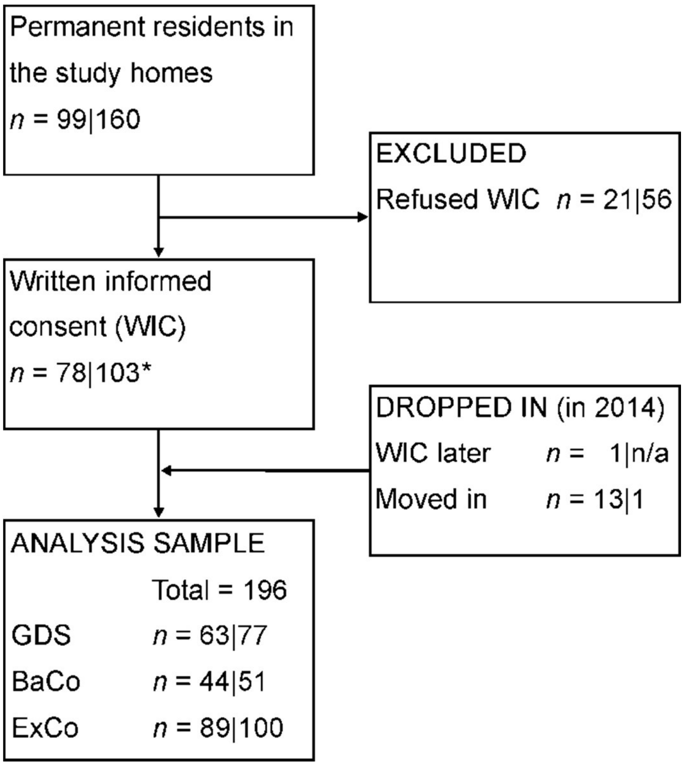
Also of importance, the process model of depressive symptoms posits disruptions of regular routines, increased negative affect, and loss of control over daily activities to mediate between the antecedents and residents' depressive symptoms (Meeks & Depp, 2003). As reasoned above, we hypothesize that dependency-provoking, disrupted daily routines may mediate between everyday competence and residents' depressive symptoms. The concept of generalized control expectancy (Rotter, 1966) appears to capture this perceived dependency versus perceived control very well. Rotter (1966) proposes two poles of the generalized expectancy of control of reinforcement: External locus of control describes the extent to which a person perceives—and with time expects—events to be out of her/his control, while internal locus of control describes the extent to which a person perceives events to be contingent on her/his action. Empirically, a review found that locus of control was associated with depression in old age (Bjørkløf et al., 2013). Therefore, perceived control was also considered as a potential mediator between both BaCo and ExCo and depressive symptoms. We state the hypothesis 2: Perceived control mediates between NH residents' BaCo as well as ExCo and their depressive symptoms cross-sectionally.

Methods

Sample

Data were drawn from the baseline measurements of the study Long-Term Care in Motion (LTCMo, Current Controlled Trials ISRCTN96090441), which installed a resident- and staff-oriented intervention aiming to promote NH residents' physical activity (Jansen et al., 2014).

Figure 3.1 Recruitment



Notes. *n*(NH 1)|*n*(NH 2). The first measurements of new study participants before 2015 were included as drop-in measurements; as post-baseline measurements in NH 2 started in 2015, these drop-ins were not included. *2|1 persons did not participate at the respective first measurement, t2 measurements were used for the two residents from NH 1.

Ethic approval for the project was obtained from the Ethic Review Board of the Faculty of Behavioral and Cultural Studies at Heidelberg University (approval letter from December 19, 2012; no code provided). Residents were approached without any pre-selection in terms of physical and mental functioning and they (or their legal representative) provided written informed consent. To enhance assessment reliability, research assistants were trained in interview techniques with NH residents, comprising dealing with cognitively impaired individuals' potential answering behavior, and received two field supervisions to provide extensive feedback on interviewers' techniques. If research assistants doubted that the resident understood the content of a question well, the answer was coded as missing. Furthermore, performance-based and proxy-rated information were collected to obtain a comprehensive picture of all residents. Figure 3.1 displays the recruitment process. Data from *n* = 196 NH residents from two homes in Heidelberg, Germany, were used. The homes were located in the same neighborhood, run by the same organization; they offered equally high care standards and similar activity programs.

Measures

Depressive Symptoms. Residents were interviewed using a German version of the 15-item *Geriatric Depression Scale* (GDS-15; Bach et al., 1995; Yesavage & Sheikh, 1986), which offers a dichotomous response format. The scale has been translated into German by the expert task force "Geriatric Assessment" (Bach et al., 1995) and showed good sensitivity and specificity in the German NH context (Allgaier et al., 2011). Since a more parsimonious GDS-12R has been suggested for use with NH residents (Sutcliffe et al., 2000), it was tested whether removal of the items "Do you prefer to stay at home, rather than going out and doing new things?", "Do you feel you have more problems with memory than most?", and "Do you think that most people are better off than you are?" downgraded the internal consistency. Computing the scale reliability for binary measures (Raykov et al., 2010) yielded $\hat{\rho}_{GDS\text{-}15} = .83$ and $\hat{\rho}_{GDS\text{-}12R} = .84$ with $\widehat{\Delta\rho}_{GDS15-GDS12R} = -.01$ (*ns*) indicating that excluding the above items did not attenuate the GDS's reliability.

The GDS-15 has been validated in old-age samples including persons with mild-to-moderate cognitive impairment (Conradsson et al., 2013). Negatively worded items were reverse-coded and GDS-12R scale scores were calculated by multiplying the mean scores (i.e., the number of depressive symptoms present divided by the number of items answered) by twelve to allow for missing data. If more than three items were missing, the scale score was set missing (Sutcliffe et al., 2000).

Basic Everyday Competence. Baltes et al. (2001) operationalized BaCo by ADL indicators and found an equally high loading of performance-based mobility measures on BaCo as of BaCo on ADL. Furthermore, several studies showed the capacity of performance-based gait speed in explaining ADL (Seino et al., 2012). Therefore, BaCo may be indicated by performance-based measures and was operationalized by two 4-m and two 10-m *walks at maximum speed* with walking times recorded in seconds (i.e., higher times indicating less functional ability) using a stop watch. Residents started from a standing stop and used their usual walking aids if necessary.

***Expanded Everyday Competence*.** According to Baltes et al. (2001), social activity is an important indicator of ExCo. ExCo was operationalized applying a proxy-rated care and behavior assessment for NHs (Köhler, Schäufele, Hendlmeier, & Weyerer, 2010) to provide reliable and NH-specific assessments for very fit, cognitively impaired, and potentially depressive residents alike. To enhance assessment reliability, questions on items were discussed with staff members and examples for activity categories were given. First, staff assessed residents' self-initiated *social contact* rating the frequency of residents' self-initiated contact with caregivers, and with other residents during the last two weeks on a scale ranging from 0 (*does not communicate*) to 2 (*approaches them often and willingly*). Second, to operationalize *activity participation*, staff members rated the frequency of residents' participation in twelve activities during the last two weeks (e.g., in-home events, entertaining activities) on a scale ranging from 0 (*never*) to 3 (*very often [nearly daily]*). One of the items was added in the present study and concerned physical activities. The item "other activation" as well as two items on outdoor activities were excluded. Four further items were excluded as most residents *never* participated in *creative activities* (73.6%), *household activities* (77.9%), *animal contact* (79.4%), or *sensory stimulation* (84.0%). In a previous validation study, the inter-rater reliabilities for social contact from three studies in German NH/residential homes were moderate to satisfactory (Köhler et al., 2010; unweighted $\kappa = .46$ to .66), but the item on participation in in-home events (the only one included in these studies) revealed quite low to moderate inter-rater reliabilities (unweighted $\kappa = .29$ to .49). In the present study, the inter-rater correlation of the social contact and activity participation sum scores for a randomly selected subgroup ($n = 10$) was satisfactorily high ($r = .95$ and $r = .80$, respectively).

Perceived Control. To keep the measurement battery as short as possible for our fragile NH population, perceived control was operationalized by the ultra-short *IE-4* (Kovaleva *et al.*, 2012), which measures internal and external control each with two items each ranging from 1 (*doesn't apply at all*) to 5 (*applies completely*). The scale was psychometrically evaluated in two large-scale samples of community-dwelling adults (aged 18+) stratified by sex, age, education, and federal state (Kovaleva, Beierlein, Kemper, & Rammstedt, 2012). In these general samples, the internal and external control components' retest-reliability and homogeneity were satisfactory ($r_{tt} = .56$ to $r_{tt} = .64$ in the first sample; $\omega = .53$ to $\omega = .64$ across samples). Given the ultra-short battery and the original proposal of a unidimensional construct (Rotter, 1966), both internal and external control components indicated a single latent perceived control factor in the present study. The external control items were reversed only to calculate the internal consistency for the four items, which was acceptable (Cronbach's $\alpha = .63$).

Covariates. Cognitive impairment, sex, calendar age, and home were included as confounding variables. No other covariates were included in the analysis for reasons of parsimony. Cognitive disability is proposed to antecede depressive symptoms (Meeks & Depp, 2003) and was related to everyday competence (Baltes et al., 2001) and depressive mood (Parmelee et al., 1989). Staff members rated residents' cognitive impairment on the seven-item *Dementia Screening Scale* (DSS), which has been developed as a proxy rating for NH residents (Köhler, Weyerer, & Schäufele, 2007). In a previous validation study, the inter-rater reliabilities from three studies in German NHs/residential homes were satisfactory (Köhler et al., 2010; unweighted $\kappa = .42$ to .79 for DSS items). The scale showed also good sensitivity (81.4%) and specificity (90.9%) when validated against the Washington University Clinical Dementia Rating (CDR) in German old-age homes (Köhler et al., 2007). Instead of the original "Could he/she orient him-/herself in his/her room?" the formulation "Did he/she know that he/she is in a nursing home?" was used, which has been used in former NH studies To enhance reliability, qualified missing categories were offered for two items (e.g., *no longer leaves the institution*) and questions on items were clarified before the first measurement. As the raters indicated for 43.2% of the sample that the item "Could he/she orient him-/herself in the neighborhood of the home?" could not be answered since the resident ceased to leave the home, the item was excluded from the measurement model. Ratings were given on a scale ranging from 0 (*always*) to 2 (*never*). The six-item scale was internally consistent (Cronbach's $\alpha = .91$) and the inter-rater correlation of the sum score was satisfactory ($r = .87$). Scale values were calculated by multiplying the mean scores of answered items by six to allow for missing data. If more than one item was missing, the scale score was set missing. Higher scores indicate more cognitive impairment in terms of memory and orientation. Residents' also rated their current vision and hearing ability in single-item questions with answer options ranging from 1 (*very bad*) to 5 (*very good*). Age was mean-centered before it was entered into the model.

Data Analysis

Descriptive analyses were performed using SAS version 9.4 (SAS Institute Inc., 2011). SEM was performed to examine latent inter-relations among the study variables using MPlus version 7.31 (Muthén & Muthén, 1998–2012). Full information maximum-likelihood estimation (FIML) was used to compensate for missing values using all available data from all respondents. Model fit was considered good for all analyses, if $\chi^2/\text{df} < 2$, root mean square error of approximation (RMSEA) ≤ .05; comparative fit index (CFI) ≥ .95, and Tucker-Lewis Index (TLI) ≥ .95. Latent modeling with categorical outcomes was used to specify the measurement models for the latent depressive symptoms, social contact, activity participation, cognitive impairment, and perceived control factors (Muthén & Asparouhov, 2002). That is, a normally distributed, continuous latent response variable y_i^* was assumed to underlie each manifest categorical variable (e.g., the GDS items), and the categorical variable's relation to its latent response variable was modeled by threshold parameters which denote the point(s) on the standard normal distribution of y_i^* dividing the response categories of the observed indicator. The latent response variable, in turn, was regressed linearly on its respective latent factor, yielding the item's loading. Please note that categorical indicator thresholds and loadings are conceptually equivalent and can be transformed to item difficulty and item discrimination parameters of item response theory's two-parameter logistic model (Muthén & Muthén, 2013). Mean- and variance-adjusted robust weighted least squares estimation was used (WLSMV; for details see Muthén & Muthén, 1998–2012). Latent factors were standardized.

First, separate measurement models were run for depressive symptoms, BaCo, ExCo, cognitive impairment, and perceived control to confirm the appropriateness of the latent construct operationalizations before fitting the full structural model of the hypothesized relationships. Concerning BaCo, the walking times were log-transformed before the analysis to approximate the normal distribution. As the gait performances are supposed to be parallel tests, equal unstandardized factor loadings were modeled for all indicators and equal intercepts and residual variances for the two 4-m and the 10-m walks, respectively.

ExCo was modeled as a latent second-order factor that was indicated by the latent social contact and activity participation factors. As the latent social contact factor was built on only two items, the item loadings of residents' contact with caregivers and their contact with other residents were set equal for model identification. Concerning residents' activity participation, an exploratory factor analysis using polychoric correlations with oblique Geomin rotation was run prior to the structural model computations. Model fit was assessed as stated above; the best-fitting model was chosen. Items would be excluded, if they loaded higher on the second factor than on the first factor. The analysis supported a two-factor model and the item *cognitive activation* was excluded as it loaded on a second factor. This resulted in a single four-item in-home activity participation factor (participation in in-home events, musical, entertaining, and physical activities) that was internally consistent (Cronbach's α = .82). The factor loadings of the latent ExCo factor on social contact and activity participation were set equal for model identification.

Second, BaCo's and ExCo's association with residents' depressive symptoms was modeled and their regression coefficients were tested for difference from zero. Moreover, a Wald test (model test) of parameter equality was conducted.

Third, additional analyses were conducted to check for the robustness of the SEM estimates. That is, a simulation was conducted that aimed to determine the power to detect the associations given our sample size and missing data patterns as well as to determine potential estimation biases (Muthén & Muthén, 2002). Parameter estimates from the measurement model (loadings, thresholds, residual variances) and from the structural model (path coefficients, covariance, residual variances) were used as population values in the simulated replications. Also, missing data patterns were generated if they occurred three or more times in the present sample. Less frequently appearing patterns were summarized in an additional pattern. A robust maximum likelihood (MLR) estimator was available for this analysis. A sample size of 196—as in the main analysis—was used for 10,000 replications. The power to detect non-zero regression paths was considered good, if it exceeded .8; the estimates were considered acceptably unbiased, if the relative biases in the point estimates as well as in their standard errors were below 5%. Then, a model including cognitive impairment, sex, age, and home as covariates was run.

Fourth, to analyze the potential mediation via perceived control, BaCo's and ExCo's direct and indirect relations with depressive symptoms were specified in a single model to analyze the potential cross-sectional mediation via perceived control.

Results

Descriptive Analysis

Regarding the GDS-12R, 140 residents provided some answers; the remaining residents refused or were too handicapped (e.g., cognitively, due to aphasia) to be interviewed. According to the 4/5 GDS-12R cut-off criterion (Sutcliffe et al., 2000), 26.0% of the residents showed clinically relevant symptoms of depression. Table 3.1 displays descriptive data of the sample.

Table 3.1 Sample Description of Study Variables

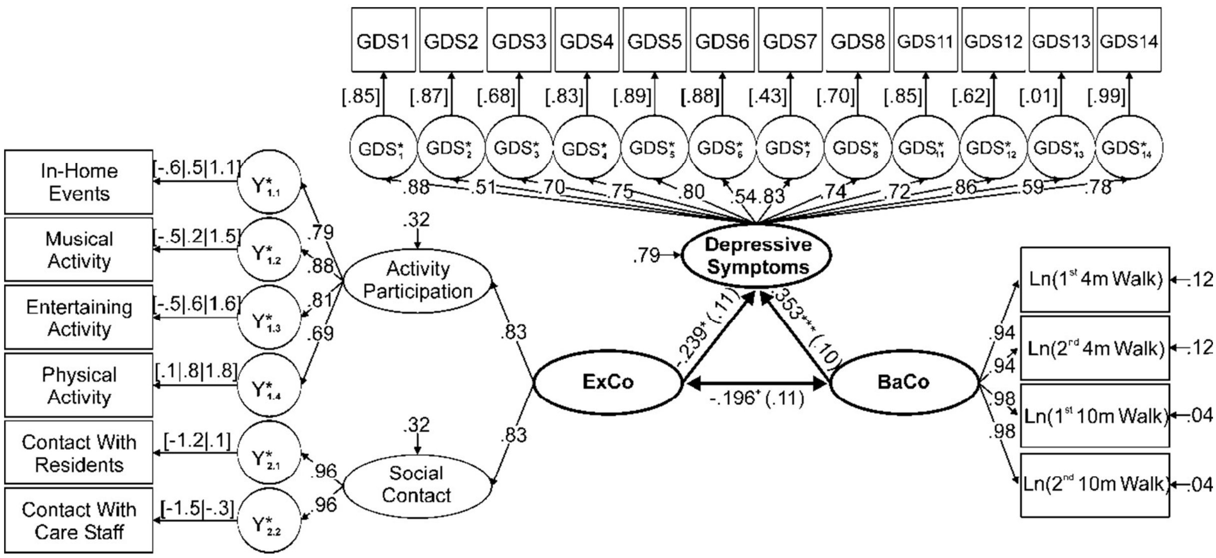
	N	Mean	SD	Range	Category Probabilities
Age (in years)	196	83.7	9.4	52.6–100.1	
Female / Male	196				.72 / .28
Home 1 / 2	196				.47 / .53
Length of Stay (in years)	196	2.4	2.1	0–8.9	
Education (in years)	135	12.0	3.8	5–25	
Single / Separated / Married / Widowed	193				.15 / .14 / .18 / .53
GDS-12R	131	2.9	3.1	0–12	
Max. Gait Speed (4-m in $^{m}/_{s}$)	95	0.79	0.35	0.21–2.00	
Max. Gait Speed (10-m in $^{m}/_{s}$)	93	0.88	0.38	0.24–2.28	
Care Level	196	1.6	0.8	0–3	.07 / .36 / .45 / .12
Contact With Care Staff	179	1.5	0.6	0–2	.06 / .34 / .60
Contact With Residents	181	1.4	0.7	0–2	.12 / .40 / .48
In-Home Event Participation	185	1.2	1.0	0–3	.27 / .41 / .19 / .13
Musical Activities	182	1.2	0.9	0–3	.31 / .28 / .34 / .07
Entertaining Activities	180	1.0	0.9	0–3	.30 / .42 / .23 / .05
Physical Activities	180	0.7	0.9	0–3	.54 / .26 / .16 / .04
Internal Control	120	3.6	1.0	1–5	
External Control	116	2.8	1.1	1–5	
DSS[1]	167	3.7	3.6	0–12	
MMSE	136	19.4	7.7	0–30	
Self-Rated Vision Ability	137	3.5	0.9	1–5	.04 / .12 / .26 / .49 / .09
Self-Rated Hearing Ability	139	3.7	0.9	1–5	.04 / .06 / .22 / .54 / .14

Notes. GDS-12R = Geriatric Depression Scale-Residential; [1]*DSS* = six items of the Dementia Screening Scale; *MMSE* = Mini-Mental State Examination.

Hypothesis 1: Latent Inter-Relations between Everyday Competence and Depressive Symptoms

The full structural model fit the data very well ($\chi^2(213) = 216.64$, χ^2 / df < 2, RMSEA = 0.009, CFI = .998, TLI = .998, 54 free parameters; see Figure 3.2). BaCo and ExCo were both significantly related to residents' depressive symptoms. A difference of one *SD* in the latent BaCo factor (i.e., an increase of one *SD* in functional impairment) was associated with a difference of .35 *SD* (bootstrapped confidence interval .12 to .56) in the latent depressive symptoms factor ($p < .001$). A difference of one *SD* in the latent ExCo factor (i.e., an increase of one *SD* in social activity) was associated with a difference of -.24 *SD* (bootstrapped confidence interval -.46 to .00) in the latent depressive symptoms factor ($p < .05$). BaCo and ExCo correlated marginally ($r = -.20$, bootstrapped confidence interval -.45 to .07, $p < .1$). Overall, residents' everyday competence in terms of BaCo and ExCo explained 21.5% of the latent depressive symptoms factor ($p < .05$).

Figure 3.2 Path Diagram of Nursing Home Residents' Depressive Symptoms Predicted by Their Basic and Expanded Everyday Competence



Notes. $\chi^2(213) = 216.64$, $p > .1$; RMSEA = 0.009; CFI = .998; TLI = .998. Standardized estimates with standard errors in parenthesis. Latent response variables y_i^* of measurement models, thresholds τ in brackets. $^+p \leq .1$; $^*p \leq .05$; $^{***}p \leq .001$.

The Wald test of equally strong relations between BaCo versus ExCo and residents' depressive symptoms was not rejected when the path coefficients were set equal ($\chi^2(1) = .49$, χ^2 / df < 2; bootstrapped confidence interval -.24 to .46).

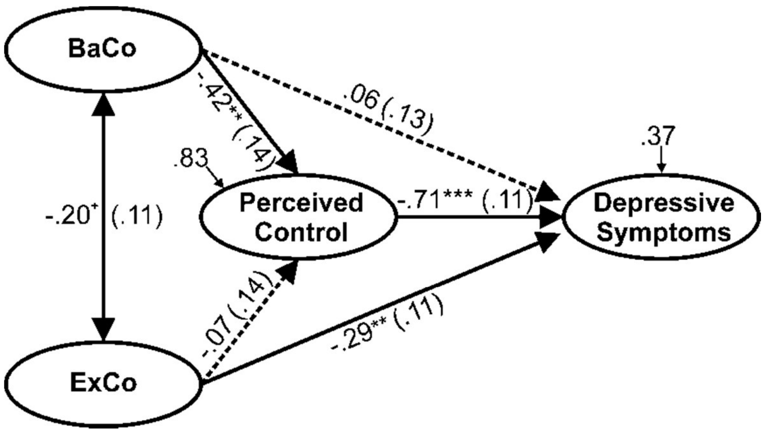
Robustness Checks

The simulation study revealed that the relative bias in the parameter estimates of the structural model—which the study focuses on and hence are relevant regarding power estimates—was below 3% with bias in standard errors below 2%. The power to detect non-zero path coefficients was acceptable (power = .82 and .76 for depressive symptoms regressed on BaCo and ExCo). The power to detect a significant correlation was .61. Concerning the measurement models, it should be noted, however, that it revealed some indication of bias in some loadings and intercepts/thresholds.

When cognitive impairment, sex, age, and home were included in the model (with all correlations between predictors set free), the model fit the data ($\chi^2(423) = 487.58$, χ^2 / df < 2, RMSEA = 0.028, CFI = .985, TLI = .983). No covariate was significantly related to depressive symptoms, but the relationships between both BaCo and ExCo with depressive symptoms did not become weaker (the path coefficients were marginally lower by -.02 and -.03, respectively). Finally, as the model complexity including all covariates may be too high (96 free parameters) taking into account the sample size, a more parsimonious version was checked by dichotomizing activity participation (0 = *never participated*), social contact (0 = *does not communicate*), and cognitive impairment items (0 = *no sign of impairment*), which yielded a model with 80 free parameters. Again, no covariates, but BaCo and ExCo were significantly related to depressive symptoms.

Hypothesis 2: Perceived Control as a Mediator between Everyday Competence and Depressive Symptoms

Figure 3.3 Structural Model of Nursing Home Residents' Depressive Symptoms Predicted by Their Basic and Expanded Everyday Competence and Their Perceived Control



Notes. $\chi^2(300) = 311.14$, $p > .1$, RMSEA = 0.014, CFI = .994, TLI = .993. Standardized estimates with standard errors in parenthesis. Dashed paths for non-significant coefficients. +$p \leq .1$; **$p \leq .01$; ***$p \leq .001$.

When perceived control was included in the model as a mediator between BaCo, ExCo, and depressive symptoms (see Figure 3.3), the model fit the data very well

($\chi^2(300) = 311.14$, χ^2 / df < 2, RMSEA = 0.014, CFI = .994, TLI = .993). Results confirmed the mediator effect of perceived control regarding BaCo, which was connected to depressive symptoms only indirectly (bootstrapped confidence interval of the unstandardized indirect effect from .06 to .71). ExCo, however, was connected to depressive symptoms only directly (bootstrapped confidence interval of the unstandardized direct effect from -.55 to -.06). BaCo, ExCo, and perceived control explained 62.9% of the latent depressive symptoms factor ($p < .001$). To deal with the high model complexity (77 free parameters), a more parsimonious version was checked again by dichotomizing the ExCo items as above and the perceived control items (0 = *internal/external control doesn't apply at all*), yielding a model with 55 free parameters. Then, BaCo was totally (i.e., direct and indirect paths combined) and ExCo was only directly significantly related to depressive symptoms.

Discussion

The interplay of BaCo and ExCo for depressed mood in older adults, particularly NH residents, has mostly remained unexplored in previous literature. We found that BaCo and ExCo were substantially associated with residents' depressive symptoms cross-sectionally. A simulation supported the path coefficients' robustness. The regression weights were both significant, which confirmed hypothesis 1; they were equally strong, and were independent of residents' cognitive impairment, sex, age, or home. Furthermore, a mediation analysis revealed that BaCo but not ExCo was related to depressive symptoms indirectly via residents' perceived control, which partly supported hypothesis 2.

Descriptively, the portion of residents who showed clinically relevant symptoms of depression was consistent with previous findings on major depressive disorder in long-term care (Hyer et al., 2005). The present sample appears as relatively fit, given that participants' maximal gait speed (using their walking aid) was in the upper range of maximal speeds found in other NH samples (Kuys, Peel, Klein, Slater, & Hubbard, 2014) and their category probabilities of the ExCo items—i.e., social contact with staff or residents and in-home activity participation—were slightly above the ones reported for another German NH sample (Köhler et al., 2010). Therefore, our findings may not be directly generalized to the full NH population.

BaCo impairment was substantially associated with residents' depressive symptoms. As we have argued, a BaCo loss may hinder a resident from performing daily activities independently, thus it may disrupt daily routines. Taking gait performance as an example, a resident may no longer be able to walk outside or she/he may have to accept the help of others, which also changes her/his daily routines and may alter the rate of positive reinforcement.

ExCo performance was also substantially associated with residents' depressive symptoms. This association is in line with the socioemotional selectivity theory which posits an increasing importance of emotionally meaningful relationships given residents' limited time horizon. The relevance of ExCo's self-initiated social contact suggests that residents can actively enlarge the number of potentially gratifying encounters. For example, a bedfast resident may often and willingly summon care staff to her/his bed. It might be interesting to explore the role of staff's reaction (i.e., the intensity of gratification provided) for residents' depressive symptoms. The association of ExCo with depressive symptoms is especially striking in the NH context, as staff work does not imply being (close) friends with residents; as other residents largely suffer from impairments (e.g., sensory, mobility-related, cognitive), which limit their ability to communicate and build gratifying relationships (Park et al., 2012); and as most in-home activities are group activities without much opportunity for close interaction between residents. ExCo's activity participation element, likewise, negatively explained their depressive symptoms. This suggests that staff may compensate for residents' functional impairments, providing opportunities for social participation and potentially reinforcing situations. For example, activity coordinators wheel non-ambulant residents to activities or offer special groups for persons with dementia.

Perceived control, as operationalized by a latent internal and external locus of control factor, mediated between BaCo but not ExCo and residents' depressive symptoms. This finding, however, should be interpreted cautiously given the restrictions of our cross-sectional data and the rather low sample size. Lower BaCo (i.e., higher walking times) was associated with lower perceived control, which in turn was associated with higher depressive symptoms. Once the mediator effect of perceived control was considered in the model, BaCo was no longer directly associated with depressive symptoms. In contrast, ExCo was associated with depressive symptoms directly and independently of perceived control, which could indicate that a resident's social activity is relevant for depressive symptoms, apart from whether she/he perceives reinforcement to depend on her/his action or not. Considering perceived control besides BaCo and ExCo nearly tripled the explained variance of depressive symptoms. This may be because perceived control is theoretically a more proximal predictor of depressive symptoms than the distant antecedent everyday competence; also perceived control shares method effects with depressive symptoms as both rely on self-reports.

Future longitudinal research is needed to more comprehensively understand the relationships between BaCo, ExCo, and residents' depressive symptoms as well as the mediating role of residents' perceived control. For example, the tripartite model of depression proposes a negative affect (or general distress) and a depression-specific positive affect factor of depression (Clark & Watson, 1991). Considering Lawton's (1983a) findings, BaCo's effect on depressive symptoms should be mediated by negative affect and ExCo's effect by positive affect. Furthermore, though ExCo was not mediated by perceived control cross-sectionally, it might be so longitudinally. For example, a person might regain perceived control if pleasant activities are increased systematically, as is part of the rationale behind the pleasant events-based behavioral intervention (Meeks & Depp, 2003). Future longitudinal studies should also investigate the effect of everyday competence on mean changes in depressive symptoms. This analysis would be especially interesting in the NH context, in which care provides a range of options to compensate for BaCo losses (Freedman & Spillman, 2014). Future studies may also trace how an individual's adaptation efforts in response to a change in BaCo or ExCo affect their intra-individual relations to depressive symptoms. For example, a resident may consciously accept her/his dependency in case of an irreversible functional impairment (Heckhausen, Wrosch, & Schulz, 2013), which could moderate BaCo's association with depressive symptoms. Once a resident has adapted to functional losses, social activity may become more important (i.e., more closely related to depressive symptoms); she/he may draw greater satisfaction from social interactions, which, in turn, should protect her/him from depressive symptoms.

Regarding limitations, first, our study is cross-sectional, wherefore the path coefficients do not imply causal relationships. Second, our sample is of restricted size and several items revealed substantial missing data ($n = 86$ participants provided answers on all three latent factors). The FIML estimation to handle missing data provides unbiased estimation under the assumption that data were missing at random (MAR; Asparouhov & Muthén, 2010). Although, the MAR condition has been considered a reasonable state-of-the-art missing data treatment (less restrictive than the missing completely at random assumption, quite robust in many cases when it does not hold; Schafer & Graham, 2002), it should be considered that non-random missing data might have biased the results. In particular, a portion of missing BaCo data may be due to walking inability or dementia-related communication barriers. However, the sample's salient missing data patterns were incorporated in the simulation analysis, which supported the robustness of our structural estimates. Third, the power to detect a significant correlation between BaCo and ExCo was only .61. Though, the present study focused on the paths between everyday competence and depressive symptoms; and this power to detect significant paths was sufficiently high (.76 and .82). Fourth, a self-report measure was used instead of clinical assessments of depressive symptoms. To acknowledge this limitation, the term *depressive symptoms* was used throughout the manuscript. Fifth, the operationalizations of BaCo and ExCo only approximate the ones originally used (Baltes et al., 2001). Though a direct ADL measure was not available and maximum gait speed comes with its own problems (e.g., the comparability of those using versus not using walking aids), it may be a good surrogate for functional ability (Seino et al., 2012). Likewise, though the yesterday interview giving detailed times per activity was not feasible in our NH sample, the staff-rated activity participation and social contact information may approximate residents' ExCo—and even more objectively. Sixth, the latent ExCo factor was developed ad hoc, wherefore its validity cannot be determined. Though the items conceptualize ExCo theoretically, wherefore we are confident that it may be validated in future studies.

In summary, this study showed the independent, substantial, and equally-sized associations of NH residents' BaCo and ExCo with their depressive symptoms using performance-based and proxy-rated predictors of subjective depression ratings and an elaborated analysis strategy. Furthermore, perceived control mediated between BaCo and depressive symptoms. Future longitudinal research may further elucidate how everyday competence impacts residents' depressive symptoms and whether losses really "initiate the depressogenic process" as theoretically stated (Lewinsohn et al., 1985, p. 344).

Conflict of Interests

None.

Description of Authors' Roles

HWW and KH designed and headed the study; they supervised the paper. MD conducted the statistical analyses. MD, HWW, and OKS interpreted the data and drafted the paper. OKS supervised the statistical analyses. CPJ, KC, and MD collected the data. All authors revised the draft.

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4

Study II: Does a Physical Activity Program in the Nursing Home Impact on Depressive Symptoms? A Generalized Linear Mixed-Model Approach

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Abstract

Objectives. Physical activity (PA) may counteract depressive symptoms in nursing home (NH) residents considering biological, psychological, and person-environment transactional pathways. Empirical results, however, have remained inconsistent. Addressing potential shortcomings of previous research, we examined the effect of a whole-ecology PA intervention program on NH residents' depressive symptoms using generalized linear mixed-models (GLMMs).

Method. We used longitudinal data from residents of two German NHs who were included without any pre-selection regarding physical and mental functioning (n = 163, M_{age} = 83.1, 53–100 years; 72% female) and assessed on four occasions each three months apart. Residents willing to participate received a 12-week PA training program. Afterwards, the training was implemented in weekly activity schedules by NH staff. We ran GLMMs to account for the highly skewed depressive symptoms outcome measure (12-item *Geriatric Depression Scale–Residential*) by using gamma distribution.

Results. Exercising (n = 78) and non-exercising residents (n = 85) showed a comparable level of depressive symptoms at pretest. For exercising residents, depressive symptoms stabilized between pre-, posttest, and at follow-up, whereas an increase was observed for non-exercising residents. The intervention group's stabilization in depressive symptoms was maintained at follow-up, but increased further for non-exercising residents.

Conclusion. Implementing an innovative PA intervention appears to be a promising approach to prevent the increase of NH residents' depressive symptoms. At the data-analytical level, GLMMs seem to be a promising tool for intervention research at large, because all longitudinally available data points and non-normality of outcome data can be considered.

Keywords: Nursing Home, Depressive Symptoms, Physical Activity Intervention, Multilevel Models, Generalized Linear Mixed-Models

Introduction

The absolute number of dependent older persons living in care institutions such as nursing homes (NH) will remain high or even increase in the Western world (e.g., European Commission & Economic Policy Committee, 2012). Among NH residents, depressive symptoms are highly prevalent with estimates as high as 61% (Meeks et al., 2011). Depressive symptoms are associated with cognitive decline, subjective health problems, impairment of activities of daily living (ADL), increased need of care, and mortality (Blazer, 2003; Fries et al., 1993).

Physical Activity and Depression in the Nursing Home Ecology

As has been argued in previous research, a promising possibility to counteract depressive symptoms in older adults is by enhancing physical activity (PA), specifically by using moderate-to-high intensity interventions on balance or progressive resistance interventions (Bridle, Spanjers, Patel, Atherton, & Lamb, 2012; Fiatarone Singh, 2002). Three causal pathways seem important to explain why an intensive PA-enhancing training may lead to fewer depressive symptoms. First, at the biological level, short- and long-term mechanisms can be expected to mediate between physical activity and fewer depressive symptoms. For example, while exercising, arousal mechanisms in the reticular-activating system are triggered which transiently balance the ventromedial cortex activity relative to that of the dorsolateral prefrontal cortex (RAH model, Dietrich & Audiffren, 2011), which are likely unbalanced in depressed persons. In the long run, exercise enhances beneficial neuro-immune effects and reduces detrimental ones (Eyre et al., 2013), which may, e.g., counteract inflammation-related increased monoamine reuptake and decreased levels of the serotonin precursor tryptophan (Massart et al., 2012). Ernst et al. (2006) also found that exercise stimulates neurogenesis, which may help abate depression-related hippocampal atrophy. Finally, exercise seems to reduce the hypothalamic-pituitary-adrenal (HPA) axis' stress reactivity (Stranahan et al., 2008), which may lead to normalizing depression-related stress sensitivity. Therefore, PA interventions should be tailored, offered frequently, and be of moderate-to-high intensity.

Second, at the psychological level, Meeks and Depp's (2003) behavioral approach to depression in the NH argues that physical disability should be seen as a significant antecedent that can increase depressive symptoms. We assume that PA training may help increase physical ability, thereby helping to regain control over daily activities and thus increasing positive reinforcement, decreasing negative (physical) self-awareness, and easing depressive symptoms. At the same time, PA training should foster enjoyable social contacts with co-residents, thus increasing positive reinforcement and alleviating residents' depressive symptoms (Meeks & Depp, 2003). This is also in line with the socioemotional selectivity theory, which claims that emotionally meaningful social contacts become more relevant as the future time perspective shrinks in old and very old age (Carstensen et al., 2003). Therefore, PA interventions should include exercises that improve residents' functional ability. Furthermore, they should comprise enjoyable co-resident contacts (e.g., by training residents in groups of comparable ability and interests).

Third, in terms of person-environment transactions in general, and with particular relevance for NH residents, Calkins' (2001) integrated model of place adds to the psychological pathway. Namely, the training may change a resident's social environment as it may establish new social contacts (e.g., between residents and the trainer, and between residents of comparable functional impairment), which, in turn, provides new opportunities for pleasant and emotionally meaningful encounters. Furthermore, the implementation of regular PA training by staff may change the organizational environment in the NH, which may then sustainably increase residents' PA behavior. This ecology change might support the sustainability of PA interventions and thus help reduce residents' depressive symptoms indirectly. Therefore, co-residents and NH staff should be involved in the training program.

Empirically, although the overall effect size was in the lower range, a meta-analysis of randomized controlled trials (RCTs) supported that PA interventions reduce depression severity in older adults including NH residents (Bridle et al., 2012). However, it is not clear whether such encouraging evidence can be fully transferred to NH residents. Indeed, findings in the NH setting have remained inconsistent thus far. While some exercise interventions supported the effect of exercise on residents' depressive symptoms in randomized trials (e.g., Tse et al., 2014; Vankova et al., 2014; Williams & Tappen, 2008), others failed to show alleviation of residents' depressive symptoms (e.g., Chin A Paw et al., 2004; Conradsson et al., 2010; Rolland et al., 2007; Underwood et al., 2013). Reasons for non-significant results may be that the PA intervention was a) not individually tailored; b) not intensive enough (Underwood et al., 2013); c) not sustained and implemented by NH staff after the study intervention, or that d) the data-analytical method was not able to extract a possibly small but meaningful intervention effect (Conradsson et al., 2010; Rolland et al., 2007). Additionally, it may have been a problem that the far from normal distribution in the depressive symptoms outcome is not addressed in typical data-analytic methods such as ANOVA models. The present study considered potential shortcomings of previous work a) by composing training groups according to residents' functional status and by offering different training modalities (group, individual, or group and serious games); b) by increasing difficulty and complexity of exercises to keep each residents' training intensity at a constant level according to her/his capacity; c) by integrating the exercise groups in the NHs' activity schedules and by handing over the training to activity coordinators to foster the intervention's sustainability, and d) by applying an analysis methodology that may help to detect small but meaningful intervention effects.

Finally, it is important to note that NH residents differ from community-dwelling older adults as residents are a highly vulnerable subpopulation of old-age individuals who are close to their life's end (Kelly et al., 2010). Therefore, residents might, on average, be in their terminal life phase, which is likely associated with terminally dropping physical functioning and an accelerated increase of depressive symptoms (Gerstorf et al., 2010; Gerstorf et al., 2013). Hence, we expect increasing depressive symptoms as a general phenomenon in untreated NH residents, but we assume that a PA training program may make a difference.

This paper uses longitudinal data of an RCT-proven PA intervention (Hauer et al., 2001; Hauer et al., 2012; Schwenk et al., 2014), which was adjusted for implementation in NHs. The overarching goal was to provide an initial evaluation of the intervention's effectiveness under naturally-occurring and thus representative conditions. Hence, the goal was not to test the intervention's efficacy under fully controlled and idealized conditions using a randomized procedure but rather to implement an already-examined intervention program in the real-world context (Gitlin & Leff, 2016) of two NHs and to examine its usefulness in a highly challenging sample. While other work addresses the intervention effect on residents' physical performance and activity (Wingerath, 2016; more to come), this paper focusses on depressive symptoms.

Hypotheses

We expect fewer depressive symptoms in residents having participated in the PA intervention compared to residents who did not participate. For non-participating residents, we expect increasing depressive symptoms across time-in-study as implied by the terminal decline literature. We expect a difference immediately following the intervention as well as three months after completion of the PA intervention.

Methods

Setting and Study Design

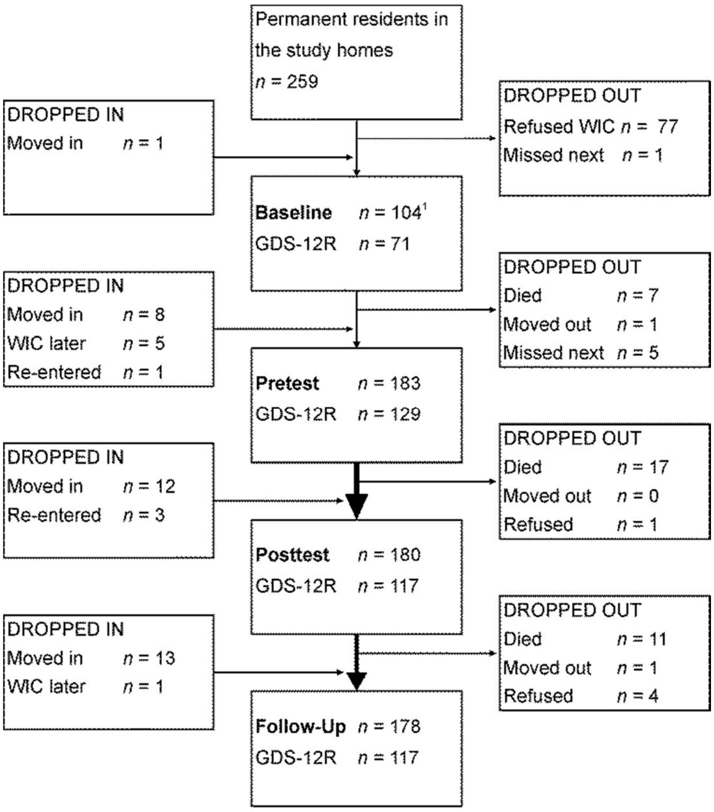
Data were drawn from the Long-Term Care in Motion study (LTCMo, Current Controlled Trials ISRCTN96090441; Jansen et al., 2014) which was part of the EU's 'innovAge—Social Innovations Promoting Active and Healthy Ageing' project. The two NHs were located in the same neighborhood in Heidelberg, Germany, run by the same organization; they offered equally high care standards, and similar activity programs. Importantly, the intervention was offered to *all* residents willing to participate, including residents with behavioral disturbances or severe functional or cognitive impairment, who were typically excluded in previous intervention work in the NH setting (e.g., Chin A Paw et al., 2004; Tse et al., 2014; Vankova et al., 2014). Hence, all non-palliative, long-term care residents were approached and they (or their legal representatives) provided written informed consent. Ethical approval for the project was obtained from the Ethic Review Board of the Faculty of Behavioral and Cultural Studies at Heidelberg University. The study conformed to the policy and mandates of the Declaration of Helsinki.

A longitudinal design was applied to track program implementation. All participants—whether in the active intervention or not—were assessed before (Pretest), after

(Posttest), and following the intervention (Follow-Up), with all assessments occurring at three month intervals. Additionally, a baseline assessment was conducted three months before the pre-intervention measurement in NH 2 to investigate residents' development under usual care (a waiting control). Residents moving into the NH and residents providing informed consent after the study start were allowed to drop in. A rather conservative criterion was applied to define the groups: residents who participated in any offered session (i.e., > 0 group, individual, or group and serious-games training session[s]) constituted the PA intervention group (PA-IG); residents who did not participate in a single session constituted the naturally-occurring control group (Nat-CG).

Figure 4.1 displays the flow of residents across the measurement occasions.

Figure 4.1 Flow of Residents



Notes. n for the number of residents participating at a given measurement occasion; [1]value for NH 2 residents only as the study started in NH 1 at pretest; *moved in* for residents who entered the NH; *written informed consent* (WIC) later for residents who had lived in the NH at the respective first measurement occasion but agreed to participate later; *re-entered* for residents who missed the previous measurement occasion; *missed next* for residents who missed the following measurement occasion; *refused* for residents who dropped out permanently for other reasons; the thick arrows marks the training and implementation periods, respectively; GDS–12R = *Geriatric Depression Scale–Residential*.

Table 4.1 Resident-Oriented Exercise Training

Intervention	Target Persons	Training Aims	Training Components	Group Size	Freq / week	Session Duration (min)
Group A	Residents • willing to participate • able to walk independently • able to stand up and sit down independently • able communicate verbally • without challenging behavior	• Increase PA in everyday life • Improve walking performance • Improve dynamic postural control • Improve sit-to-stand/sit-to-walk transfer	• Dynamic balance and gait training ○ Different standing positions ○ Improvement of stability and duration of standing posture ○ Different walking exercises (e.g., narrow vs. wide distance between feet; slow vs. fast walking; uneven floor surfaces) • Functional strength training ○ Sit-to-stand transfer training without using the arms	4–8	2	45
Group B	Residents • willing to participate • able to walk with aid • able to stand up and sit down independently • able communicate verbally • without challenging behavior	• Increase PA in everyday life • Improve static and dynamic postural control • Improve sit-to-stand transfer • Later: Support of stable walking, walking security, and a homogeneous walking pattern	• Static and dynamic balance and gait training ○ Different standing positions ○ Improvement of stability and duration of standing posture ○ Different walking exercises with support (e.g., with aid, promoting homogeneous walking pattern, with supervision) • Functional strength training ○ Sit-to-stand transfer training ○ Later: Sit-to-walk transfer training	4–8	2	45

(continued on next page)

Table 4.1. Resident-Oriented Exercise Training *(continued)*

Intervention	Target Persons	Training Aims	Training Components	Group Size	Freq / week	Session Duration (min)
Dementia-Care Group	Residents • willing to participate • living on demented-care unit • may have severe cognitive, behavioral, and/or psychological symptoms	• Increase PA in everyday life • Improve static and dynamic postural control • Improve sit-to-stand transfer • Later: Support of stable walking, walking security, and a homogeneous walking pattern • Support transformation of wandering behavior into meaningful exercising activities	• Static and dynamic balance and gait training ○ Different standing positions ○ Improvement of stability and duration of standing posture ○ Different walking exercises with support (e.g., narrow vs. wide distance between feet; slow vs. fast walking; uneven floor surfaces) • Functional strength training ○ Sit-to-stand transfer training without using the arms • Focus on social group training aspects ○ Exercising together using meaningful tasks ○ Participants are allowed to leave and rejoin the training session	4–8	2	45

(continued on next page)

Table 4.1. Resident-Oriented Exercise Training *(continued)*

Intervention	Target Persons	Training Aims	Training Components	Group Size	Freq / week	Session Duration (min)
Serious Games	Residents • participating in group training • willing to participate • able to stand and step without aid • without severe cognitive impairment	• Increase PA in everyday life • Improve dynamic postural control • Improve cognitive and dual-task performance	• Cognitive-motor training ○ Step training (forward, backward, right or left) on a dance plate as indicated on a TV screen • Dynamic balance and gait training ○ Different standing positions ○ Improvement of stability and duration of standing posture • Cognitive task including spatiotemporal orientation and executive functions	3–4	1	15 / per resident
Individual	Residents • willing to participate • able to stand with close supervision and support • may have severe motor, cognitive, behavioral, and/or psychological symptoms • without aggressive behavior	• Support of dynamic sitting • Improve sit-to-stand transfer	• Seated strength and mobilization training • Later: Standing exercises with support • For ambulatory residents: Adaption of Group A/B exercises according to a resident's functional abilities	1	1 (NH 1) 2 (NH 2)	30

Notes. All residents with written informed consent were eligible for the intervention; those willing to participate could choose in which of the exercise components they would like to participate; residents could participate in multiple exercise components; the training lasted 12 weeks and was afterwards continued by activity coordinating staff (another 12 weeks till follow-up).

Description of the Intervention Program

We implemented a training program for NH residents that was based on empirical support from RCTs assessing geriatric patients with dementia (Hauer et al., 2012). The training was adapted to the needs and resources of NH residents and enriched by additionally offering a serious-games training and an individual training. We also included a staff training component in one of the NHs to enhance residents' PA in everyday life. To test whether the staff training affected depressive symptoms differentially in the NH where staff were trained, we included interactions of home and training indicators in the statistical model. However, these interactions were not significant ($p > .05$), while the main treatment effects remained significant. Therefore, the staff training is not discussed more broadly in this article. A guidebook with detailed information on the implementation steps and training is available (Jansen et al., 2015). Table 4.1 displays the intervention components as well as inclusion criteria for the exercise groups.

LTCMo aimed at changing residents' PA *behavior*. To achieve this goal, the PA-enhancing program offered multiple training components for specific subgroups of residents, all of whom were allowed to participate in several intervention components. Supplementary to training in a group setting, residents could play serious games. This training was meant to motivate residents to be physically active by offering a game setting in which residents have to step (forward, backward, right, or left) on a dance plate as indicated on a computer or TV screen. Residents were approached and encouraged to participate in the resident-oriented exercise training. Those willing to participate could choose to exercise in a group, individually, or in a group and in serious games according to their wishes and their functional status (as assessed before the intervention's start). Once residents started the training, they stayed with their chosen option(s). The training utilized dementia-associated communication strategies and techniques to handle behavioral challenges especially in the closed wards. Residents were grouped homogeneously according to their functional status and the training difficulty progressed according to each resident's increasing capabilities to optimally promote PA. For example, the training differed between groups of residents being able to walk (Group A), or to stand (Group B), and those living on the dementia-care unit (Dementia-

Care Group; see Table 4.1). Importantly for our follow-up measurement and the training program's sustainability, the main training components except serious games were transferred to activity coordinators of both NHs after completion of the 12-week training program. Namely, activity-coordinating staff were trained extensively to continue the exercises professionally; they integrated exercise sessions into their weekly in-home activity schedules, and they received supervision to foster quality of implementation.

Procedure

At every measurement occasion, research staff (CPJ, ELS, Katrin Claßen, MD) and assistants interviewed residents, which included psychosocial measurements. They obtained performance-based measurements of ambulatory residents' functional status, and research staff collected demographic and medication-related data from the NHs' care documentations (for details, see Jansen et al., 2014). As cognitive impairment in NH residents is very common, and as all residents were allowed to participate in the study, research assistants were trained in interview techniques with cognitively impaired residents, including dealing with potential response behavior. Each research assistant also received two field supervisions to get extensive feedback on his/her techniques. If he/she doubted that the resident understood the content of a question, the answer was coded as missing.

Measures

Depressive Symptoms. Residents were assessed using the German 12-item Geriatric Depression Scale–Residential (GDS–12R; Bach et al., 1995; Sutcliffe et al., 2000), which was developed for use in NH residents. It excludes the items "Do you prefer to stay at home, rather than going out and doing new things?", "Do you feel you have more problems with memory than most?", and "Do you think that most people are better off than you are?" that may be ambiguous in the NH context (Sutcliffe et al., 2000). The GDS–12R offers a dichotomous response format and has been validated in old-age samples including persons with mild-to-moderate cognitive impairment (Conradsson et al., 2013). Negatively worded items were reverse-coded and scale values were calculated by multiplying the mean scores (i.e., the number of depressive symptoms divided by the number of items answered) by the number of scale items to control for missing items. If more than three items were missing, the scale score was set as missing (Sutcliffe et al., 2000). Resulting scores range from 0 to 12, with higher scores indicating more depressive symptoms. The scale's internal consistency was good at all measurements (Cronbach's α between .81 and .87).

Covariates. Residents rated their currently *perceived vision* on a scale ranging from 0 (*very bad*) to 4 (*very good*). They also answered the ultra-short IE-4 (Kovaleva et al., 2012), which measures *internal* and *external control*, each with two items ranging from 1 (*does not apply at all*) to 5 (*applies completely*). Other potential covariates considered are residents' age, sex, living on dementia-care unit, length-of-stay, death-related dropout, education, family status, maximal gait speed, independent mobility, and perceived hearing. Furthermore, residents' pharmacological treatment with antidepressants was recorded following the Anatomical Therapeutic Chemical classification codes (ATC code N06A for antidepressants; 0 = *does not receive antidepressant treatment*, 1 = *receives antidepressant treatment*). The number of sessions attended was also recorded.

Generalized Linear Mixed-Models to Test the Intervention Effect

To examine the intervention effect on depressive symptoms in the NH, generalized linear mixed-models (GLMMs; Hedeker, 2005) for longitudinal data were used. This innovative method for examining intervention effects is based on linear mixed models, which include, besides fixed linear predictor variables, random variances to account for cluster-related correlations in the data (namely, several measurement occasions per resident). GLMMs consider all available data points, including residents who missed some test occasions, which conforms to the study aim of including all residents. Furthermore, *generalized* linear mixed models can handle non-normal outcome distributions, which is important as depressive symptoms are likely to be highly skewed in old-age samples (e.g., Schilling et al., 2016). The basic model (M1) tested was

$$g(\mu_{it}) = \beta_0 + \beta_1 T_{it} + \beta_2 NH_i + \beta_3 PAPOS_{it} + \beta_4 PAFUP_{it} + U_{0i} + U_{1i}T_{it} \quad (4.1)$$

with $g(\cdot)$ a distribution-dependent link function and μ_{it} the expected depressive symptoms value of resident i at time t. The βs denote fixed and the Us random effects. T_{it}

refers to time-in-study, modelling a potential linear increase in depressive symptoms across the observation period. Note that $T_{it} = 0$ may refer to pretest (NH 1) or to the baseline measurement before pretest (NH 2, see also Figure 1). U_{1i} denotes the respective random effect (allowing for inter-individually varying linear time trends). NH_i denotes a dummy variable indicating resident i's NH to control for potential site effects. $PAPOS_{it}$ and $PAFUP_{it}$ denote dummy variables indicating post-intervention measurement in the PA-IG (i.e., coded 1 for the post measurement of training participants but 0 otherwise) and follow-up measurement in the PA-IG, respectively. Hence, β_3 tests the immediate PA promotion effect on residents' depressive symptoms at posttest, and β_4 tests the sustainability of the intervention three months post intervention, at follow-up. Notably, the linear time trend and home affiliation were partialled out of these intervention effects. This methodology allows for testing intervention effects directly and may serve as an alternative to modelling time × group interactions, which requires post-hoc tests of intervention-related differences.

To correct for non-randomization statistically, covariates were included into Model 2 (M2), in which the PA-IG and the Nat-CG potentially differ at pretest. Furthermore, a covariate × treatment indicator interaction was included to test for differential covariate-related training effects. Thus, M2 tested the intervention effect when significant pretest covariate differences between the PA-IG and the Nat-CG besides the home effect and the time trend were partialled out.

To further check the intervention effects' robustness, pretest levels of demographics (age, sex, living on dementia-care unit) and of internal and external control (see Diegelmann, Wahl et al., 2017) were included in the model. Continuous variables' pretest values were grand-mean centered before being added to models (M2 and M3). Only Level-2 covariates were added (M2 and M3), i.e., the starting level of depressive symptoms was allowed to depend on the covariates' pretest levels. GLMMs with Laplace approximation (to obtain maximum likelihood-based fit statistics) and the empirical estimator were run using PROC GLIMMIX (SAS Institute Inc., 2011). Model fit was assessed using the portion of intra-individual variance explained by the model estimates following Xu's (2003) operationalization of R^2 as the reduction of residual variance of the model tested (σ^2) compared with the residual variance of the random intercept-only null model (σ_0^2), i.e., $R^2 = 1 - \sigma^2 / \sigma_0^2$.

Results

Sample Description

Table 4.2 displays the descriptive data of the sample. Notably, the sample size varies according to the information source, with the largest sample sizes for information from the obligatory care documentation, smaller samples for interview data as some residents were too handicapped to be interviewed (e.g., due to cognitive impairment, aphasia), were absent (e.g. in hospital), or refused to participate, and smallest sample sizes for performance-based measures that are available only for ambulatory residents. Table 4.2 includes bootstrap step-down-corrected *p* values from *t*-tests and Fisher's exact tests comparing the PA-IG and the Nat-CG on potential covariates at pretest. Importantly, the PA-IG and the Nat-CG did not differ in their pre-intervention depressive symptom levels. According to the 4/5 GDS–12R cut-off criterion (Sutcliffe et al., 2000), 27.0% of the residents showed clinically relevant symptoms of depression at pretest. However, the PA-IG had a better perceived vision than the Nat-CG ($p < .05$).

Comparing the pretest values (GDS–12R, intervention group participation, age, sex, home, living on dementia-care unit, length-of-stay, education, antidepressant medication, gait speed, immobility, perceived vision, perceived hearing, internal and external control) for residents who dropped out for any reason vs. those who completed the study yielded no group differences (all corrected *p* values > .05).

Table 4.2 Descriptive Data and Pretest Group Comparison

Variable	Nat-CG *n*	Nat-CG *M* (Median)	Nat-CG *SD*	Nat-CG Category Probabilities	PA-IG *n*	PA-IG *M* (Median)	PA-IG *SD*	PA-IG Category Probabilities	Range	*p*
GDS–12R$_{Baseline}$	38	2.9 (2.0)	3.0		33	3.6 (2.7)	3.4		0–12	
GDS–12R$_{Pretest}$	57	3.4 (3.0)	3.0		72	2.8 (2.0)	3.0		0–11	.87
GDS–12R$_{Posttest}$	49	4.1 (3.6)	3.6		68	2.7 (1.2)	3.0		0–11	
GDS–12R$_{Follow\text{-}up}$	54	3.7 (3.3)	3.4		63	3.0 (1.1)	3.3		0–12	
Age (yr)	57	83.0	10.8		72	84.0	9.9		52.9–100.4	.98
Female / Male	57			.70 / .30	72			.71 / .29		1
Home 1 / 2	57			.30 / .70	72			.50 / .50		.27
Not / Living on Dementia Unit	57			.95 / .05	72			.76 / .24		.07
Length-of-Stay (yr)	57	2.7	2.3		72	2.2	1.7		0.0–9.2	.85
Alive / Death-Related Dropout	57			.79 / .21	72			.90 / .10		.57
Education (yr)	53	12.1	3.3		66	12.1	4.2		5–25	1
Single / Separated / Married / Widowed	57			.25 / .21 / .12 / .42	72			.11 / .14 / .14 / .58		
No / Antidepressant Treatment	55			.69 / .31	71			.68 / .32		1
Gait Speed (10-m / s)	11	1.1	0.4		61	0.9	0.4		0.2–2.0	.67
Immobile / Mobile	56			.21 / .79	72			.06 / .94		.14
Perceived Vision	56	2.2	1.1		71	2.7	0.8		0–4	.02
Perceived Hearing	57	2.6	1.0		71	2.7	1.0		0–4	1
Perceived Internal Control	49	3.8	1.0		65	3.6	1.0		1–5	.98
Perceived External Control	50	2.9	1.2		60	2.7	1.1		1–5	.93

Notes. Nat-CG = naturally-occurring control group; PA-IG = physical activity intervention group; GDS–12R = Geriatric Depression Scale–Residential; all variables but GDS–12R are displayed for pretest; bootstrap step-down-corrected *p* values to correct for multiple testing using PROC MULTTEST (SAS Institute Inc., 2011) for variables treated as interval-scaled from *t*-tests and for dichotomous variables from Fisher's exact tests; significant *p* value in bold.

Adherence

Eighty-three residents consented to participate in the intervention program. Of these, 62 were trained in groups ($n_{\text{NH 1|NH 2}}$ = 36|26; $n_{\text{drop-outs}}$ = 5; n_{deceased} = 2), 21 individually ($n_{\text{NH 1|NH 2}}$ = 5|16; $n_{\text{drop-outs}}$ = 2), and 17 of those in the group training additionally participated in serious games ($n_{\text{NH 1|NH 2}}$ = 9|8; $n_{\text{drop-outs}}$ = 3). Residents dropping out of the individual training never participated and were counted among the Nat-CG. Adherence was high with 85% (range: 4%–100%) for 24 group training sessions, 78% (range: 45%–100%) for 21 individual training sessions, and 82% (range: 8%–100%) for 12 serious-games sessions. Using pretest data, ANOVA testing yielded no significant differences in depressive symptoms (GDS–12R) between the training modalities (no vs. group vs. individual vs. group and serious games; $F(3) = 1.48$, $p > .05$). Considering this finding, the small sample size in the different modalities, and the goal of examining the overall effect of the training program, binary training indicators for ever vs. never participating were used. In both NHs, training activities were successfully handed over to activity coordinators of the facility for autonomous continuation of the program after completion of the study.

Preparatory Analyses

The depressive symptoms score showed substantial right-skewness across residents and measurement occasions (median = 2.0, range = 0–12, skewness = 0.9, kurtosis = -0.2). The Anderson-Darling fit statistic—a squared difference statistic—indicated that the gamma distribution ($A^2 = 10.0$) was more appropriate for modeling the outcome than the normal distribution ($A^2 = 18.5$), although neither fit perfectly (both A^2 with $p < .01$). Other continuous, right-skewed distributions explored (beta, lognormal, exponential) showed worse fit than gamma distribution (larger A^2), but better fit than normal distribution. We conclude that the gamma distribution is the best distribution model for the mixed-model analyses. To fit the gamma distribution, the outcome was shifted to exclude zero (i.e., GDS–12R + 1).

Effect of a PA Intervention on Resident's Depressive Symptoms

Table 4.3 displays GLMM results of the intervention effects on residents' depressive symptoms. Please note that the regression coefficients are on a logarithmic-scale (link function for the gamma distribution) rather than on the original depressive symptoms' scale. Therefore, the coefficients do not refer to the marginal mean of depressive symptoms conditional on the predictors, but to the linear predictor $g(\mu_{it})$. Nevertheless, the effect signs and significance tests can be interpreted as usual.

Table 4.3 Generalized Linear Mixed-Models of Depressive Symptoms Regressed on Time-in-Study, Home, Intervention Indicators, and Pretest Covariates

Parameter	M1	M2	M3
Fixed Effects (*SE*)			
Intercept	1.29 (0.08)***	1.24 (0.08)***	1.34 (0.09)***
Time-in-Study [Months]	0.03 (0.01)*	0.03 (0.01)*	0.02 (0.01)
NH 1	-0.21 (0.11)$^{+}$	-0.13 (0.12)	-0.18 (0.12)
Post-Intervention in the PA-IG	-0.22 (0.08)**	-0.20 (0.09)*	-0.24 (0.09)*
Follow-Up in the PA-IG	-0.27 (0.12)*	-0.27 (0.12)*	-0.23 (0.13)$^{+}$
Perceived Vision		-0.09 (0.06)	0.08 (0.06)
Age [Years]			0.01 (0.01)
Male			-0.04 (0.13)
Living on Dementia-Care Unit			-0.23 (0.14)$^{+}$
Perceived Internal Control			-0.35 (0.05)***
Perceived External Control			0.13 (0.05)*
Random Variances (*SE*)			
Intercept	0.37 (0.06)***	0.36 (0.06)***	0.16 (0.05)***
Covariance	0.00 (0.01)	0.00 (0.01)	0.01 (0.01)
Time-in-Study	<0.01 (0.00)	<0.01 (0.00)	<0.01 (0.00)
Residual	0.21 (0.03)***	0.20 (0.03)***	0.20 (0.03)***
R^2	.08	.10	.11

Notes. Models estimated using the gamma link function in SAS PROC GLIMMIX (SAS Institute Inc., 2011); R^2 following Xu (2003) with residuals on the data scale of M and the random intercept-only model, respectively; n(M1) = 163 with 434 observations; n(M2) = 136 with 395 observations; n(M3) = 104 with 310 observations; $^{+}$ $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$.

Initially, residents of the two NHs did not differ in their depressive symptoms scores ($\beta = -0.21$, $p > .05$). However, the random intercept variance indicates that residents varied significantly around these mean starting values. Depressive symptoms increased in the Nat-CG through the course of the study ($\beta = 0.03$, $p < .05$). This developmental trend was, however, different for the PA-IG who showed significantly fewer depressive symptoms than the Nat-CG both immediately and three months after the intervention (β = -0.22 and β = -0.27, respectively, both $p < .05$). Considering R^2, 8% of the intra-individual variance of depressive symptoms was explained by time-in-study, training participation, and home affiliation. Post-hoc analyses revealed that depressive symptoms stabilized rather than decreased in the PA-IG as the post and follow-up effects did not significantly differ from the expected depressive symptoms score at pretest (both $p > .05$). Residents' depressive symptoms development did not significantly differ from these group-specific trajectories as indicated by the non-significant random slope variance.

Check of Robustness

As the Nat-CG and the PA-IG differed in perceived vision (see Table 4.2), we ran M2 to control for this pretest difference. Perceived vision did not influence residents' depressive symptoms and the pattern of time and intervention effects remained unchanged (see Table 4.3). Likewise, when the perceived vision × treatment effects interactions were included, time, post- and follow-up treatment effects remained significant while all covariate-related effects were not significant (all $p > .05$, data not shown).

The post-intervention effect persisted (β = -0.24, $p < .05$) when, besides perceived vision, residents' age, sex, living on dementia-care unit, and perceived internal and external control at pretest were considered (M3). The effect following up the intervention, however, turned marginal in significance (β = -0.23, $p = .08$), while its absolute value was comparable to the post-intervention effect. Of the covariates considered, only perceived internal and external control showed significant effects on the depressive symptoms starting level (β = -0.35 and β = 0.13, respectively, both $p < .05$) with more internal control and less external control being associated with fewer depressive symptoms. Notably, the number of sessions attended did not significantly affect residents' depressive symptoms when added to the model, while both intervention effects remained significant and the pattern of covariates remained as reported in M3 (data not shown).

Discussion

The present study showed the average beneficial effect of a whole-NH ecology, multi-component PA training on NH residents' depressive symptoms. As expected, the analyses showed a linear increase of depressive symptoms in the Nat-CG. However, the PA-IG's depressive symptoms remained stable and were, also as expected, significantly fewer compared to the Nat-CG both immediately and three months after the intervention. Furthermore, the post-intervention effect was maintained when pretest-levels of perceived control and demographic variables were partialled out. This sustainability and robustness of the intervention effect argues for the usefulness of closely analyzing NHs' activity schedules and possibilities, of training activity coordinators in delivering PAs regularly, and of integrating these exercises in their schedule (for details, see Jansen et al., 2015). Future research should evaluate the implementation effect over a longer period.

Several approaches may explain these findings. The PA intervention may have elicited positive effects at various biological levels as argued in the introduction (Dietrich & Audiffren, 2011; Ernst et al., 2006; Eyre et al., 2013; Fiatarone Singh, 2002).To stimulate biological pathways that are involved in reducing depressive symptoms, residents were trained in homogeneous groups using group-specific exercises, and the training difficulty was increased according to their progress. At the psychological level, the training offered choice options (group or individual training, or group and serious games), improved residents' physical ability (Wingerath, 2016), and came with social contact with young trainers and comparably fit co-residents. In terms of person-environment transaction, the training may have increased the NH system's support of residents' PA behavior, e.g., exercise groups were handed over to NH staff, who possibly established a sustainable change regime regarding residents' PA behavior. All of these aspects may have jointly contributed to the effect observed.

Although we only provided initial evidence that the implementation of a previously established PA intervention for frail, multi-morbid persons with cognitive impairment (Hauer et al., 2012) is successful also for NH residents, we believe that such an intervention may prove particularly useful to counteract depressive symptoms because of its potentially multi-pathway impact. Certainly, the PA intervention may be accompanied by depression-specific interventions such as psychotherapeutic consultation in the NH ecology (Meeks et al., 2015). However, a PA training approach has the advantage of reaching a considerable number of residents at the same time. However, we also found that many residents did not seem eager to accept a PA interventional approach. Hence, PA training could become part of a multi-component program in the NH setting that may also contain psychosocial consultation and pleasant events-based behavioral interventions in general (see also Diegelmann, Wahl et al., 2017; Meeks et al., 2015), e.g., dancing or social conversation (Vankova et al., 2014; Williams & Tappen, 2008).

Regarding the implementation of a PA intervention in the natural NH ecology, it seems important to consider that NHs are highly structured institutions with many well-established routines. Apart from the overarching structure, staff and residents often have diverging interests, which makes evaluating and respecting the concerns of all involved parties essential. According to our experience, three main principles should guide the implementation: 1) inform the whole system in consideration of the hierarchical structures; 2) learn about and evaluate existing activities and programs within the institution with respect to project aims, integrating them into a program when possible; and 3) respect established and successful structures and the work of the staff involved (see Jansen et al., 2015).

Besides these training-related implications, the present study suggests that applying GLMMs may help analyze intervention effects in future work. Although some researchers reported null results of exercise against depression in the NH (Chin A Paw et al., 2004; Conradsson et al., 2010; Rolland et al., 2007; Underwood et al., 2013), it may well be that methodological aspects beyond the training-related aspects blurred the results. In particular, the traditional ANOVA approach has its limitations regarding the accommodation of non-normal outcome distributions and the deletion of cases with missing data points. Instead, the present study used GLMMs for a non-normally distributed outcome and effect-indicators to model differences between the PA-IG and the Nat-IG at the time points of interest directly (i.e., the intervention effects). This strategy can be expected to reduce estimation bias. Furthermore, GLMMs allow considering all available data points, including those of residents with intermittent or permanent drop-out, which increases the power to detect a meaningful effect. Finally, they allow specifying the intervention effect(s) of interest very flexibly. This was helpful for our implementation design under natural circumstances but may also be helpful for the analysis of classical RCT designs.

Limitations

It seems challenging to consider an RCT as a design for an implementation that aims to include all residents in the real world of NH ecologies (Hodgson & Gitlin, 2016). While an RCT-like design may have strengthened the evaluation of our PA intervention, the present study showed the effect of an already evaluated intervention as implemented in the natural NH ecology. Further, as we cannot rule out that an unmeasured covariate influenced whether or not a resident participated, a causal effect of our intervention cannot be claimed. Nevertheless, the study investigated the implementation under natural conditions (high ecological validity) and controlled for the only apparent difference between the PA-IG and the Nat-CG statistically (see Table 4.2). We also acknowledge that theoretically promising mediating factors, as named in the introduction, like training-related biological changes, have not been tracked. Future research may pick up these measures and examine their mediating role in more detail. Finally, we used a dimensional scale rather than a clinical measure of depression, which is why we used the term *depressive symptoms* rather than depression throughout the study.

Conclusion

In summary, the present study provides emerging support for the potential of an innovative, whole-ecology, multi-component, PA-enhancing program able to positively impact on residents' depressive symptoms. Depressive symptoms of untreated residents further increased across nine months, whereas PA-trained residents maintained their pretest level throughout the study. It will be interesting to see how future research uses modern data analytic methods (e.g., GLMMs) to investigate the effect of innovative multi-level interventions to counter depressive symptoms in the NH ecology.

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Disclosure of Interest

The authors report no conflicts of interest.

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Study III: Understanding Depressive Symptoms in Nursing Home Residents: The Role of Frequency and Enjoyability of Different Expanded Competencies Relevant to the Nursing Home Setting

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Abstract

Depressive symptoms are highly prevalent in nursing home (NH) residents. We assume that enjoyability, besides frequency of activities, is an important facet of expanded everyday competence (ExCo; M Baltes et al. 2001) and affects residents' depressive symptoms. Furthermore, we assume that associations with depressive symptoms vary for different ExCo-related activities, namely contact with co-residents and staff and participation in organized in-home activities. To investigate these associations, longitudinal data from 160 residents (M_{age} = 83.1 years, *SD* = 9.8 years, 73% female) of two German NHs, assessed across four measurement occasions each three months apart, were analyzed. Depressive symptoms were assessed by the Geriatric Depression Scale–Residential (GDS-12R); ExCo domains and their enjoyabilities were assessed via proxy ratings and interviews, respectively. As data from the completed Long-Term Care in Motion intervention study were used, 49% of the sample also received a physical activity intervention. Generalized linear mixed models were run to test the hypothesized effects as flexibly as possible, accounting for non-normality of the GDS-12R and controlling for residents' intervention status. The results showed that the effect of enjoying contact with co-residents was moderated by co-resident contact frequency with the least depressive symptoms for residents who frequently have enjoyable contact. Both frequency and enjoyability of staff contact were only marginally associated with fewer depressive symptoms. Likewise, enjoying participating in in-home activities was associated with fewer depressive symptoms. In conclusion, the findings support our conceptually-driven expectation of differential effects in terms of different ExCo-related activities on depressive symptoms.

Keywords: Nursing Home, Depressive Symptoms, Everyday Competence, Social Activity, Pleasant Events

Introduction

The absolute number of dependent older persons receiving institutionalized care will remain high or even rise in the Western world (European Commission & Economic Policy Committee, 2012). Among nursing home (NH) residents, clinically relevant depressive symptoms are highly prevalent with estimates of up to 61% (Meeks et al., 2011). Depressive symptoms merit research attention as they are associated with cognitive decline, subjective health problems, impaired activities of daily living (ADL), increased need of care, and mortality (Blazer, 2003; Fries et al., 1993).

To conceptualize depressive symptoms, the current study primarily relies on Lewinsohn's well-established behavioral approach to depression (Lewinsohn, 1974; Lewinsohn et al., 1985), which has been adapted to explain depression in NH residents (Meeks & Depp, 2003). Lewinsohn (1974) distinguishes between the *frequency* and *enjoyability* of activities. According to Lewinsohn, the interplay of the frequency and enjoyability of activities determines the reinforcing value of a given activity, which then affects an individual's depressive symptoms. Hence, we argue that activity enjoyability needs to be considered besides activity frequency to understand the role of reinforcement as a proximal predictor of residents' depressive symptoms.

Empirically, available studies support the importance of pleasant activities for older community-dwelling adults' and NH residents' low depressive symptoms (Lewinsohn & Graf, 1973; Meeks, Young, & Looney, 2007). Successful behavioral treatments for depression in NH residents have built on Lewinsohn's theory, i.e., increased the frequency of pleasant activities (e.g., Konnert et al., 2009; Meeks et al., 2015). However, more research is needed to disentangle the effects of frequency versus enjoyability of different everyday activities on depressive symptoms in the NH ecology.

Besides the overall distinction between frequency and enjoyability, Lewinsohn (1974) distinguished between distinct activity domains (e.g., bodily, cognitive, social) which are expected to be differentially associated with depressive symptoms. Previous empirical findings also support the need to differentiate these activity domains in predicting depressive symptoms in older adults (Lewinsohn & Graf, 1973; Meeks et al., 2007; Meeks & Looney, 2011). Following this reasoning, the present study examines differential associations of qualitatively different everyday social activities and their respective enjoyabilities with residents' depressive symptoms. To conceptualize everyday activities, we refer to the established everyday competence model proposed by M Baltes et al. (2001).

This model distinguishes basic (BaCo) from expanded everyday competence (ExCo),[5] the latter being the focus of the present study. ExCo comprises activities that primarily stem from individual preferences and inter-individually different motivational states and elicit meaning in life beyond basic self-preservation (Baltes et al., 2001). Moreover, the socioemotional selectivity theory claims that emotionally meaningful social goals become more relevant as an individual's future time perspective shrinks (Carstensen et al., 2003). Accordingly, potentially reinforcing social activities could be especially important for alleviating depressive symptoms of NH residents who generally represent a vulnerable subpopulation of old-age individuals close to life's end (Freedman & Spillman, 2014). Empirical support comes from studies showing that a perceived loss of activity participation or perceived friendliness of staff and co-residents were associated with residents' depressive symptoms (Mortenson et al., 2012; Park, 2009).

We further assume that contact with co-residents, contact with care staff, and participation in offered in-home activities are particularly important ExCo-related domains in the daily ecology of NH residents. In an early observational study, Baltes et al. (1983) found that 35% of residents' social contacts were with co-residents, and 50% with staff, meaning that these are the most prominent social interactions in the NH. Current research also shows that contact with co-residents and staff is more important to residents' depressive symptoms than contact with family or friends (Cheng, Lee, & Chow, 2010).

Self-initiated contact with co-residents may be associated with fewer depressive symptoms. As institutional routines might determine contact frequency to a considerable extent, the frequency of *self-initiated* contacts may be particularly important. Self-initiated co-resident contacts may have the character of being most

[5] Though focusing on competence, they operationalized BaCo and ExCo by activities; therefore, activity will be used to refer to BaCo and ExCo.

'normal' and informal, and may have the strongest overlap with social contacting in earlier life. Additionally, residents may control how often they have contact with whom, which should induce well-being and reduce depressive symptoms (Herzog, Franks, Markus, & Holmberg, 1998). Following Lewinsohn (1974), we additionally assume that the more enjoyable co-resident contacting is, the stronger the association with fewer depressive symptoms. That is, if the contact is perceived as enjoyable, residents may gain hedonic rewards, which are assumed to counteract depressive symptoms (Lewinsohn et al., 1985; Meeks & Depp, 2003).

However, self-initiated co-resident contact may or may not be enjoyable. It may be enjoyable as co-residents belong to the same in-group, may face comparable emotional strains, and may be able to share pleasures from the same events or activities. Otherwise, it may be unpleasant as co-residents largely suffer from impairments (e.g., sensory, mobility-related, cognitive), which may limit their ability to communicate and to build enjoyable, gratifying relationships (Park et al., 2012). Therefore, enjoyable self-initiated co-resident contacts may only be associated with fewer depressive symptoms if they occur more frequently than unpleasant co-resident contacts; i.e., contact frequency is expected to moderate the effect of contact enjoyability on residents' depressive symptoms. Supporting this notion empirically, unmet needs regarding company (e.g., due to infrequent or unpleasant contacts) were found to be more common in depressed compared to non-depressed NH residents (Ferreira, Dias, & Fernandes, 2016); further, greater perceived co-resident friendliness (i.e., contact enjoyability) was associated with fewer depressive symptoms (Park, 2009).

Regarding *self-initiated contact with care staff*, we expect different associations. Here, the frequency of staff contact may not be associated with fewer depressive symptoms. The frequency of self-initiated staff contact depends on institutionalized routines, which minimize residents' chances to control how often they have contact with staff members. Moreover, the frequency of initiating staff contact may represent residents' need of care, which might be associated with more, rather than fewer depressive symptoms. Enjoyable staff contacts, however, may be associated with fewer depressive symptoms. Supporting this notion empirically, perceived staff friendliness was associated with fewer depressive symptoms (Park, 2009) but caring for residents typically did not imply close friendship with residents (Park et al., 2012).

Next, for *participating in organized activities within the NH*, the frequency may not be associated with fewer depressive symptoms as most activities are organized groups with limited opportunity for experiencing social-emotionally gratifying encounters. However, participation enjoyability may be associated with higher reinforcement. Therefore, the enjoyability of activity participation rather than its frequency may be associated with fewer depressive symptoms. As emerging empirical support, we note that correlations between activities like entertainment and residents' depressive symptoms were observed for the enjoyability rather than the frequency of activities (Hsu & Wright, 2014).

This paper uses longitudinal data of a completed BaCo-related physical activity intervention study in the NH (Jansen et al., 2014) to examine the long-term interplay of activity enjoyability and depressive symptoms in NH residents. Building on previous findings, which found that both residents' higher BaCo and ExCo were associated with fewer depressive symptoms (Diegelmann, Wahl et al., 2017) and that training participants showed fewer depressive symptoms after the training than non-participants (Diegelmann, Jansen et al., 2017), we used the training data to address more fundamental questions related to the linkage of enjoyability and depressive symptoms in NH residents.

Research Questions and Hypotheses

Based on the reasoning outlined above, we examine two overarching research questions: How do ExCo-related activities and their enjoyabilities predict residents' depressive symptoms? How do the associations vary for different ExCo-related activity domains?

For self-initiated co-resident contact, we expect the interaction of contact frequency and enjoyability to be associated with lower depressive symptoms. Precisely, we expect the fewest depressive symptoms for residents having frequent and enjoyable co-resident contacts. For staff contact and participation in organized in-home activities, we expect an effect of enjoyability, but not of frequency on residents' depressive symptoms.

Methods

Setting and Study Design

Data were drawn from the Long-Term Care in Motion study (LTCMo, Current Controlled Trials ISRCTN96090441; Jansen et al., 2014), an intervention study aiming at enhancing residents' physical activity behavior in the NH. Residents from two NHs in Heidelberg, Germany participated. The NHs were located in the same neighborhood, run by the same organization; they offered equally high care standards and similar activity programs. All non-palliative, long-term care residents were approached. Residents (or their legal representatives) provided written informed consent. Ethical approval for the project was obtained from the Ethic Review Board of the Faculty of Behavioral and Cultural Studies at Heidelberg University. The study conformed to the respective policy and mandates of the Declaration of Helsinki.

The current study used a longitudinal design including the quasi-experimental physical activity promotion program of the completed LTCMo trial. Parts of the program aimed at improving residents' BaCo. Residents were assessed before (pretest), after (posttest), and following the intervention (follow-up) with all assessments occurring at three month intervals. Additionally, a baseline assessment was conducted three months before the pretest in NH 2 to investigate residents' development under usual care. Residents moving into the NHs and residents consenting after study start were allowed to drop in.

Sample

Descriptive information on study variables is displayed in Table 5.1. The analyzed sample consisted of 160 residents.[6] At participants' first measurement occasions, 28% showed clinically relevant depressive symptoms according to the GDS-12R cut-off criterion (Sutcliffe et al., 2000). Residents were aged 83.1 (*SD* = 9.8 years), 73% were female, and 52% were widowed; they had an average of 12.2 years of education. Of the participants, 61% resided in NH 2, 16% lived on a dementia-care unit. No dementia diagnosis was available, but following Paquay et al. (2007), 44% were cognitively

[6] Sample size reductions in the presented GLMM-models are due to missing data on covariates.

Table 5.1 Sample Description of Study Variables

	T_0		T_1		T_2		T_3		
Variable	*n*	Mean (*SD*)	*n*	Mean (*SD*)	*n*	Mean (*SD*)	*n*	Mean (*SD*)	Range
Geriatric Depression Scale—Residential (GDS-12R)	124	3.0 (3.1)	128	3.0 (3.0)	111	3.4 (3.3)	71	3.9 (3.7)	0–12
Self-Initiated Contact With Co-Residents	116	0.6 (0.5)	113	0.6 (0.5)	106	0.6 (0.5)	63	0.6 (0.5)	0, 1
Enjoys Talking With Co-Residents	117	0.4 (0.5)	119	0.4 (0.5)	107	0.5 (0.5)	66	0.3 (0.5)	0, 1
Self-Initiated Contact With Staff	113	0.7 (0.5)	112	0.6 (0.5)	106	0.7 (0.5)	66	0.7 (0.5)	0, 1
Enjoys Talking With Staff	114	0.5 (0.5)	117	0.6 (0.5)	107	0.6 (0.5)	64	0.6 (0.5)	0, 1
Activity Participation	117	3.8 (2.4)	114	3.1 (2.2)	109	3.4 (2.2)	63	3.0 (2.3)	0-9
Enjoys Participating	118	0.5 (0.5)	120	0.5 (0.5)	102	0.5 (0.5)	63	0.5 (0.5)	0, 1

Notes. *T* referring to time-in-study with T_0 being the first measurement occasions in the respective NHs, T_3 was only available in NH 2.

impaired (*MMSE* ≤ 19). Half of the residents (49%) participated in the BaCo-related intervention. Considering a resident's first participation, bootstrap step-down-corrected *p* values from *t*-tests and Fisher's exact tests did not show any differences between trained and untrained residents on model-relevant variables (all $p > .05$).

Measures

Depressive Symptoms. At all measurement occasions, residents were assessed using the German 12-item Geriatric Depression Scale–Residential (GDS-12R; Sutcliffe et al., 2000), which was developed for use in NH residents. It excludes the items "Do you prefer to stay at home, rather than going out and doing new things?", "Do you feel you have more problems with memory than most?", and "Do you think that most people are better off than you are?" that may be ambiguous in the NH context (Sutcliffe et al., 2000). The GDS offers a dichotomous response format and has been validated in old-age samples including persons with mild-to-moderate cognitive impairment (Conradsson et al., 2013). To acknowledge that a self-report measure was used instead of clinical assessments, the term *depressive symptoms* is used throughout the manuscript. To enhance assessment reliability, research assistants were trained in interview techniques with cognitively impaired residents, including dealing with potential answering behavior. Each research assistant also received two field supervisions to get extensive feedback on his/her techniques. If he/she doubted that the resident understood the content of a question, the answer was coded as missing. Negatively worded items were reverse-coded and scale values were calculated by multiplying the mean scores (i.e., the number of depressive symptoms divided by the number of items answered) by the number of scale items to control for missing items. If more than three items were missing, the scale score was set as missing (Sutcliffe et al., 2000). Resulting scores ranged from 0 to 12, with higher scores indicating more depressive symptoms. The scale's internal consistency was good (Cronbach's α between .81 and .86 for all measurement occasions).

Expanded Everyday Activity. Baltes et al. (2001) operationalized ExCo by working, leisure, and social activities. In the present study, ExCo was operationalized by in-home leisure and social activities. We applied a care and behavior assessment for NHs (Köhler et al., 2010) rated by activity-coordinating NH staff. First, staff assessed residents' self-initiated *social contact with co-residents* and *with staff*, rating the frequency of residents' self-initiated contact during the past two weeks on a scale ranging from 0 (*does not proactively communicate*) to 2 (*approaches others often and willingly*). These two items were dichotomized for the analyses to indicate whether a resident self-initiated social contact with co-residents or staff *often and willingly* or *not often and willingly*.

Activity coordinating staff rated the frequency of residents' *activity participation* in twelve activities during the last two weeks on a scale ranging from 0 (*never*) to 3 (*very often [nearly daily]*). In keeping with previous analyses, we used the frequency of participation in in-home events, musical activities, and entertainment activities (Diegelmann, Wahl et al., 2017), but excluded participation in in-home physical activities (like seated gymnastics) to avoid confoundation with participation in the training (LTCMo). LTCMo participation was included explicitly in the model. To enhance assessment reliability, questions on items were discussed with staff members and examples for activity categories were given. Scale values were calculated by multiplying the item mean scores by the number of scale items to control for missing items. If more than one item was missing, the scale score was set as missing. The score ranged from 0 to 9, with higher scores indicating more frequent participation., and was internally consistent (Cronbach's α between .74 and .81 for all measurement occasions).

Enjoyability. Following the Pleasant Events Schedule—Nursing Home Version (Meeks, Shah, & Ramsey, 2009), residents also were interviewed about the enjoyability of "Talking with another resident", "Talking with care staff or activity coordinators", and "Participating in a group activity (Morning meeting, current events, singing)"[7] using single items ranging from 0 (*not at all pleasant*) to 2 (*very pleasant*). These were also dichotomized for the analyses to indicate whether a resident rated an activity as *very pleasant* or *not very pleasant*.

Covariates. Emerging findings support the idea that the physical activity promotion program is indeed able to stabilize depressive symptoms, which is assumed to be achieved via biological, psychological, social, and environmental pathways (Diegelmann,

[7] That is, a single enjoyability item was used for the in-home activity score.

Jansen et al., 2017). Therefore, training participation was included in the statistical model. Residents who participated in LTCMo's training were considered as belonging to the intervention group; residents who did not participate in at least one session were considered as naturally-occurring control group. Furthermore, residents' home affiliation, sex, and age-at-pretest were obtained from the care documentation. Additionally, residents' cognitive ability was tested using the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). MMSE scores were calculated by multiplying the mean scores (i.e., the number of correct items divided by the number of items answered) by the number of test items to control for missing items. If more than four items were missing, the scale score was set as missing. The MMSE ranges from 0 to 30 with higher scores indicating better cognitive performance. For the analyses, the grand-mean centered person-mean of MMSE was used, so that the difference between the sample's mean MMSE and a person's average score across all measurement occasions was controlled.

Data Analysis

To examine linkages between the frequency and enjoyability of ExCo-related activities and depressive symptoms, generalized linear mixed models (GLMMs; Hedeker, 2005) for longitudinal data were used. The role of each ExCo-related activity domain (co-resident contact, staff contact, participation in organized in-home activities) was investigated in a separate model. GLMMs were chosen because they consider all available data points including those for residents who missed some occasions, thus improving power because they fit models to non-normal outcome distributions. First, the main effects of ExCo frequency and enjoyability on depressive symptoms were tested (M1); then, interactional effects were tested between activity participation and enjoyability (M2). The basic model tested (without interactions) was

$$g(\mu_{it}) = \beta_0 + \beta_1 ACT_{it} + \beta_2 ENJ_{it} + \beta_3 T_{it} + \beta_4 PAPOS_{it} + \beta_5 PAFUP_{it} + \beta_6 NH_i + \beta_7 SEX_i + \beta_8 AGE_i + \beta_9 MMSE_i + U_{0i} \quad (5.1)$$

with $g(\cdot)$ a distribution-dependent link function, μ_{it} the expected depressive symptoms value of resident i at measurement occasion t. The βs denote fixed effects and U_{0i} a random effect. ACT_{ti} denotes a dummy variable indicating activity participation of resident *i* at measurement occasion *t*;[8] whereas ENJ_{ti} is a dummy variable indicating whether this activity has been perceived as enjoyable or not. T_{it} refers to time-in-study, controlling for a potential (linear) change in depressive symptoms across the observation period.[9] $PAPOS_{ti}$ and $PAFUP_{ti}$ refer to the effects of the BaCo-related training as follows: $PAPOS_{ti}$ denotes a dummy variable indicating posttest measurement (i.e., coded 1 for the posttest measurement of residents that took part in the intervention, and 0 for all of their other measurement occasions and all measurement occasions of the residents who did not take part in the intervention), hence β_3 tests the BaCo-related intervention effect at posttest. $PAFUP_{ti}$ denotes a dummy variable indicating training follow-up measurement (i.e., coded 1 for the follow-up measurement of residents who participated in the intervention, and 0 otherwise), hence β_4 tests the intervention's sustainability at follow-up (Diegelmann, Jansen et al., 2017). NH_i denotes a dummy variable indicating resident *i*'s NH to control for potential effects of the home affiliation; SEX_i controls for gender-specific effects, AGE_i for age effects at pretest, and $MMSE_i$ for residents' cognitive ability.

GLMMs with Laplace approximation (to obtain maximum likelihood-based fit statistics) and the empirical estimator were run using PROC GLIMMIX (SAS Institute Inc., 2011). Model fit was assessed using the portion of intra-individual variance explained by the model estimates following Xu's (2003) operationalization of R^2 as the reduction of residual variance of the model tested (σ^2) compared with the residual variance of the random intercept-only null model (σ_0^2), i.e., $R^2 = 1 - \sigma^2 / \sigma_0^2$. If hypothesized effects were marginally significant, they are reported.

As the GDS-12R items "Have you dropped many of your activities and interests?" and "Do you often get bored?" may overlap with the item "participation in in-home physical

[8] Except for activity participation, for which an interval-scaled and grand mean-centered activity score was used.

[9] Note that $T_{it} = 0$ indicates NH-specific first measurements, hence it may refer to pretest (NH 1) or to the baseline measurement before pretest (NH 2). Moreover, as the respective random-slope variance was close to zero in previous analyses (Diegelmann, Jansen et al., 2017) and caused convergence problems in the present analyses, it was discarded from the models.

activity groups" and may thus introduce some bias, the activity participation analyses were done excluding those items.

Results

Descriptive Data

Correlations between study variables are depicted in Table 5.2. Pearson correlations are displayed which are equal to point biserial correlations between interval-scaled and dichotomous variables (correlations with depressive symptoms and activity participation; Kornbrot, 2014) and also to the φ-coefficient of the association between dichotomous variables (Chedzoy, 2014). The highest correlation was found for self-initiated co-resident contact with staff contact ($\varphi = .70$, $p < .001$). Frequency and enjoyability were only weakly correlated for co-resident contact ($\varphi = .22$, $p < .05$), not significantly correlated for staff contact ($\varphi = .17$, $p > .05$), but higher for activity participation ($r = .36$, $p < .001$).

Preparatory Analyses

The depressive symptoms score showed substantial non-normality across residents and measurement occasions (median = 2, range = 0–12, skewness = 0.9, kurtosis = -.2). That is, the score was highly right-skewed. The Anderson-Darling fit statistic—a squared difference statistic—indicated that the gamma distribution ($A^2 = 10.0$) was more appropriate for modeling the outcome than the normal distribution ($A^2 = 18.5$), though neither fit perfectly (both A^2 with $p < .01$)[10]. To fit the gamma distribution, the outcome was rescaled to exclude zero (i.e., GDS-12R + 1).

[10] Other continuous, right-skewed distributions checked (beta, lognormal, exponential) showed worse fit than the gamma distribution (larger A^2), but better fit than the normal distribution. We conclude that the gamma distribution was the best distribution model for the mixed model analyses.

Table 5.2 Correlations of Study Variables

	GDS-12R	CR	ER	CS	ES	AC	PO	FU
Geriatric Depression Scale—Residential (GDS-12R)								
Self-Initiated Contact With Co-Residents (CR)	-.15							
Enjoys Talking With Co-Residents (ER)	-.24 **	.22 *						
Self-Initiated Contact With Staff (CS)	-.03	.70 ***	.21 *					
Enjoys Talking With Staff (ES)	-.14	.01	.42 ***	.17				
Activity Participation (AC)	-.17	.41 ***	.08	.32 ***	.04			
Enjoys Participating (EA)	.01	.29 **	.28 **	.23 *	.27 **	.36 ***	-.02	-.07
Training Group Post Intervention[a] (PO)	-.20 *	.13	-.06	.02	.02	.06		
Training Group Following-Up Intervention[b] (FU)	-.10	.10	.01	-.01	-.01	.08		
Home 1	.11	-.20 *	-.09	-.18	-.03	-.30 ***	-.06	-.08
Male	-.06	-.21 *	-.15	-.21 *	-.13	-.28 **	.06	.07
Age at Pretest	-.11	.13	.13	.07	-.17	.10	.10	.09
Mini-Mental State Examination	.18 *	.07	-.21 *	.05	.10	-.18	-.12	-.16

Notes. Values in the lower triangular part denote between-subject (inter-individual) correlations at residents' first measurement occasion; [a]correlations for this variable at the post-intervention measurement; [b]correlations for this variable at the measurement following-up the intervention; $^{*}p \leq .05$; $^{**}p \leq .01$; $^{***}p \leq .001$.

Expanded Everyday Activity and the Role of Enjoyability for Depressive Symptoms

Table 5.3 displays the GLMM results. Across all ExCo-related activities, residents' depressive symptoms significantly increased over nine months between baseline and follow-up measurement if residents did not participate in the BaCo-related training (all $p < .01$ for T). The training effects were shown most consistently across activity domains and despite controlling for covariates (all $p < .05$ for posttest; all $p < .1$ for follow-up, except for activity participation). That is, while depressive symptoms increased for non-participating residents, they stabilized in the training group. Furthermore, males suffered from fewer depressive symptoms than females (except for the co-resident contact model; all other $p < .06$) and residents with better cognitive performance on the MMSE suffered from significantly, though only little more depressive symptoms (all $p < .01$).

Self-initiated social contact with co-residents. Both frequent self-initiated contact with co-residents and contact enjoyability were significantly associated with fewer depressive symptoms (both $p < .05$; see M1 in Table 5.3). Additionally, an interactional effect between self-initiated co-resident contact and its enjoyability emerged ($p < .05$; see M2 in Table 5.3). That is, residents, who initiated co-resident contact *often and willingly* and who enjoyed it, showed fewer depressive symptoms than all other residents (see Table 5.3) after controlling for training and covariate effects.

Self-initiated social contact with care staff. Both frequent self-initiated staff contact and contact enjoyability were marginally associated with fewer depressive symptoms (both $p < .1$; see M1 in Table 5.3). No interactional effect of frequency and enjoyability was obtained (see M2 in Table 5.3).

Activity participation. As expected, enjoyable rather than frequent participation in organized in-home activities was associated with fewer depressive symptoms ($p < .05$; see M1 in Table 5.3). When the interaction was added in M2, it did not have a significant effect on residents' depressive symptoms ($p > .05$; see M2 in Table 5.3) but the effect of participation enjoyability remained stable. When the analyses were repeated using the whole GDS-12R scale including potentially overlapping activity items, participation enjoyability was only marginally associated with fewer depressive symptoms ($p < .1$).

Table 5.3 Generalized Linear Mixed Models of Depressive Symptoms Regressed on ExCo-Related Activity, the Respective Enjoyability, and Covariates

	Co-Resident Contact[a]		Staff Contact[b]		Activity Participation[c]	
	M1	M2	M1	M2	M1	M2
Parameter	Est (*SE*)	Est(*SE*)	Est (*SE*)	Est (*SE*)	Est (*SE*)	Est (*SE*)
Fixed Effects						
Intercept	1.31 (0.10)***	1.32(0.10)***	1.39 (0.10)***	1.39 (0.11)***	1.28 (0.09)***	1.28 (0.09)***
ACT	-0.15 (0.08)*	-0.06(0.09)	-0.13 (0.07)$^{+}$	-0.13 (0.09)	-0.01 (0.02)	0.00 (0.02)
ENJ	-0.14 (0.07)*	0.02(0.09)	-0.12 (0.07)$^{+}$	-0.12 (0.11)	-0.16 (0.06)**	-0.15 (0.06)*
ACT × ENJ		-0.26(0.13)*		-0.01 (0.12)		-0.02 (0.03)
T [Months]	0.04 (0.01)**	0.04(0.01)**	0.03 (0.01)**	0.03 (0.01)**	0.03 (0.01)**	0.03 (0.01)**
PAPOS	-0.20 (0.08)*	-0.19(0.08)*	-0.19 (0.08)*	-0.19 (0.08)*	-0.23 (0.08)**	-0.23 (0.08)**
PAFUP	-0.24 (0.11)*	-0.23(0.11)*	-0.23 (0.11)*	-0.23 (0.12)$^{+}$	-0.18 (0.11)	-0.18 (0.11)
NH 1	-0.07 (0.11)	-0.08(0.)	-0.09 (0.11)	-0.09 (0.11)	-0.13 (0.11)	-0.13 (0.11)
Male	-0.20 (0.12)	-0.20(0.12)	-0.24 (0.12)$^{+}$	-0.24 (0.12)$^{+}$	-0.24 (0.12)*	-0.24 (0.12)*
Age-at-Pretest[d]	0.00 (0.01)	0.00(0.01)	-0.01 (0.01)	-0.01 (0.01)	0.00 (0.01)	0.00 (0.01)
MMSE[e]	0.02 (0.01)***	0.02(0.01)***	0.02 (0.01)**	0.02 (0.01)**	0.03 (0.01)***	0.03 (0.01)***
Random Variances						
Intercept	0.33 (0.05)***	0.33(0.04)***	0.34 (0.05)***	0.34 (0.05)***	0.32 (0.04)***	0.32 (0.04)***
Residual	0.21 (0.02)***	0.20(0.02)***	0.21 (0.02)***	0.21 (0.02)***	0.18 (0.02)***	0.18 (0.02)***
R^2	.09	.10	.09	.09	.11	.11

Notes. Models estimated using the gamma link function in SAS PROC GLIMMIX (SAS Institute Inc., 2011); ACT = activity dummy for the respective ExCo-related domain (co-resident contact, staff contact, or participation in organized in-home activities); ENJ = enjoyability dummy; PAPOS = dummy indicating posttest in BaCo-related physical activity training group; PAFUP = dummy indicating follow-up measurement in BaCo-related physical activity training group; T = Time-in-Study; [a]*n* = 157 with 374 observations; [b]*n* = 154 with 368 observations; [c]*ACT* in this model refers to a scale rather than an indicator and the outcome was the GDS-12R without activity-related items, *n* = 157 with 370 observations; [d]grand-mean centered; [e]grand-mean centered person-mean of the Mini-Mental State Examination score; $^{+}$ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$; R^2 following Xu (2003) with residuals on the data scale of M and the random intercept-only model, respectively.

Discussion

Descriptively, one quarter of the present sample showed clinically relevant depressive symptoms, which is consistent with previous findings on major depressive disorder in long-term care (Meeks et al., 2011). Therefore, it can be assumed that our sample was not very biased in terms of mental health. Further, we found support for the assumption that ExCo enjoyability has great reinforcing value because it predicted lower depressive symptoms across all activity domains considered. For activity frequency, an effect was observed only in interaction with co-resident contact enjoyability, which may show the relevance of considering activity enjoyability in future depressive symptoms-related research and interventions. Furthermore, participants of the BaCo-related training showed fewer depressive symptoms than untrained residents following the intervention across all ExCo domains considered. This effect was robust to ExCo-related activity and enjoyability as well as to covariate effects. All of these were partialled out in the presented models and the result conforms to previous findings (Diegelmann, Jansen et al., 2017).

We found, also as hypothesized, differential patterns between ExCo-related activity domains, their enjoyabilities, and residents' depressive symptoms. For contact with co-residents, self-initiated contact moderated the enjoyability effect conforming to our hypothesis. That is, frequently initiating pleasant co-resident contact may have shifted the balance toward more enjoyable than unpleasant encounters. The relevance of both co-resident contact frequency and its enjoyability is in line with the socioemotional selectivity theory which claims an increasing importance in emotionally meaningful relationships as the future-time perspective shrinks (Carstensen et al., 2003). This finding also supports the relevance of meaningful contact with residents which has been emphasized in earlier work (Baltes, Wahl, & Reichert, 1991) and has recently been promoted by the *resident engagement and peer support* model (Theurer et al., 2015).

Unexpectedly, neither the frequency nor the enjoyability of staff contact was significantly related to fewer depressive symptoms. As both effects were, however, at the border of significance, future research may investigate this effect using a larger sample and include potential covariates like staffing ratio or perceived staff friendliness to better understand the associations with depressive symptoms.

For regularly offered in-home activities, higher enjoyability was, as expected, associated with fewer depressive symptoms and irrespective of participation frequency. The absent participation frequency effect is consistent with previous research which found that organized activities are unlikely to improve positive affect in residents not suffering from high depression (Meeks et al., 2007).

Limitations

Some issues should be kept in mind when interpreting these results. First, the combination with an intervention study may be problematic; however, an analytical approach most suitable to the data was chosen, as it allows statistically accounting for the effect of intervention participation. Second, we used dichotomous rather than metric measures of activity frequency[11] and enjoyability. Therefore, we cannot investigate the causal relationship between a change in activity and/or enjoyability and a subsequent change in depressive symptoms as proposed by theory (Meeks & Depp, 2003). However, dichotomizing appeared as suitable given our three-tiered items. Third, the operationalization of ExCo only approximates the one originally used (Baltes et al., 2001). However, the operationalization was theoretically driven to operationalize the original constructs and the measures are assumed to be more objective than the originally used interview-derived measures. Besides, the measures used allowed us to examine the association between ExCo-related domains and depressive symptoms differentially. Fourth, challenges from working with institutions have complicated our commitment to strict research standards of data generation. That is, the proxy-rated measures could not be obtained at the same date as the interview data but, rather, with a delay of several days to weeks (no exact dates provided). Furthermore, a change in a law caused a change in activity-coordinating staff in NH 2 after baseline. Therefore, the rater for a single resident could change across time, especially in NH 2.

Conclusion

This study is, to the best of our knowledge, the first to investigate the differential associations between domains of ExCo-related activities, their enjoyabilities, and

[11] Except for activity participation which was treated as interval-scaled.

residents' depressive symptoms longitudinally. The frequently found argument that *activity* in the NH setting is good for depressive residents finds important differentiations in this work and the basic associations underlying pleasant events-based interventions in NHs are addressed. Future research may follow up these findings and investigate the effect of systematic combinations of BaCo-related trainings with pleasant activities like enjoyable co-resident contact.

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Conflict of Interest

The authors declare that they have no conflict of interest.

6

Study IV: Life-Space and Movement Behavior in Nursing Home Residents: Results of a New Sensor-Based Assessment and Associated Factors[12]

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[12] According to §4 of the *Guidelines for preparing a publication-based dissertation at the Faculty of Behavioral and Cultural Studies* (July 1, 2012), using papers from co-authorships with other doctoral students in publication-based dissertations is possible. Study IV will also serve as part of the set of papers in Carl-Philipp Jansen's dissertation. Therefore, I focus on the findings which are relevant to residents' depressive symptoms only. I also confirm that I contributed substantially to this paper (helping with data gathering, screening and managing data, commenting on the theoretical background, conducting regression analyses, producing Figure 6.2, revising and approving the draft). Together with my supervisor, Prof. Dr. Hans-Werner Wahl, we decided to include the paper as a 4th publication in my set of papers.

Abstract

Background. Studies on life-space (LS) and its determinants have previously been limited to community-dwelling subjects but are lacking in institutionalized older persons. The purpose of this study was to provide an advanced descriptive analysis of LS in nursing home residents and to identify associated factors based on an established theoretical framework, using an objective, sensor-based assessment with a high spatiotemporal resolution.

Methods. Cross-sectional study in two nursing homes in Heidelberg, Germany (n = 65; M_{age} = 82.9 years; 2/3 female). Changes of location in the nursing home (Transits) as well as time spent away from the private room (TAFR) were assessed using a wireless sensor network. Measures of physical, psychosocial, cognitive, socio-demographic, and environmental factors were assessed via established motor performance tests, interviews, and proxy-reports.

Results. LS of residents was largely restricted to the private room and the surrounding living unit (90%); 10% of daytime was spent outside the living unit and/or the facility. On average, TAFR was 5.1 hours per day (± 2.3; Range: 0–8); seven Transits (6.9 ± 3.2; Range: 0–18) were performed per day. Linear regression analyses revealed being male, lower gait speed, higher cognitive status, and lower apathy to be associated with more Transits; higher gait speed, lower cognitive status, and fewer depressive symptoms were associated with more TAFR. LS was significantly increased during institutional routines (mealtimes) as compared to the rest of the day.

Conclusions. The sensor-based LS assessment provided new, objective insights into LS of institutionalized persons living in nursing homes. It revealed that residents' LS was severely limited to private rooms and adjacent living units, and that in institutional settings, daily routines such as meal times seem to be the major determinant of LS utilization. Gait speed, apathy, and depressive symptoms as well as institutional meal routines were the only modifiable predictors of Transits and/or TAFR, and thus have greatest potential to lead to an enhancement of LS when targeted with interventions.

Trial Registration. Current Controlled Trials ISRCTN96090441 (retrospectively regist.)

Keywords: Life-Space, Nursing Home, Sensor-Based Assessment, Spatiotemporal Movement Behavior

Background

Considerable efforts have been made to increase quality of care and quality of life in nursing home (NH) residents in the past decades (Castle & Ferguson, 2010; Wiener, 2003), but physical and social inactivity still remain a large concern in modern nursing facilities. As research has shown, the majority of NH residents spend their time inactively sitting or lying alone (den Ouden et al., 2015; Ice, 2002). A measure that has been positively associated with physical activity as well as social participation in community-dwelling older adults (Polku et al., 2015; Tsai et al., 2015) and NH residents (Mortenson et al., 2012) is life-space (LS). LS has been conceptualized as the spatial extension of an individual's environment that he/she moves in during a specified time period (May et al., 1985; Tsai et al., 2015), irrespective of the types of conducted activity, use of walking aids, or other assistance (Stalvey et al., 1999). In general, greater LS implies that an individual has more opportunity to visit personally meaningful places and to interact socially with others (Lawton & Simon, 1968). To highlight the complexity of factors influencing LS in older adults, Webber et al. (2010) presented a theoretical framework in which LS mobility in old age is assumed to be influenced by cognitive, psychosocial, physical, socio-demographic, financial, and environmental dimensions. The model has found partial empirical support in previous research which has demonstrated associations between LS mobility and physical performance (Baker et al., 2003; May et al., 1985; Tung et al., 2014), global cognitive functioning (Barnes et al., 2007), and psycho-social factors including depression (Baker et al., 2003; Simmons, Schnelle, MacRae, & Ouslander, 1995; Tung et al., 2014), concerns about falling (Uemura et al., 2013), and apathy (Tung et al., 2014) in community-dwelling older persons.

Applying the LS framework in NH residents—an institutionalized group of older persons with multiple impairments—poses the question whether the determinants identified in community-dwelling older subjects can also be verified for LS in NH residents. Institutions such as NH are expected to have pronounced characteristics that strongly determine life and behavior within them (Goffman, 1961). Such characteristics are, for example, architectural features (e.g., special care units, meeting places); care routines; or institution-dependent organizational schedules including meal times and weekly recurring and highly standardized events (Calkins, 2001; Tinetti & Ginter, 1990). That said, we assume that the framework of Webber et al. (2010) may largely be valid also for the NH setting, but needs additional qualification in that the institutional factors impacting on behavior may play a key role in determining LS.

LS has mostly been assessed in- and outside of the private home environment (Baker et al., 2003; May et al., 1985; Stalvey et al., 1999; Thielke et al., 2014). Self-report measurements as the *Life-Space Diary* (May et al., 1985), the *University of Alabama at Birmingham Study of Aging Life-Space Assessment* (Baker et al., 2003), or the *Life-Space Questionnaire* (Stalvey et al., 1999) were predominantly used, providing a composite score of LS across a defined time period. Regarding NH residents, only one measure has been introduced to our knowledge, a proxy rating titled *Nursing Home Life-Space Diameter* (NHLSD; Tinetti & Ginter, 1990). Such subjective LS assessments—self- or proxy ratings—come with multiple weaknesses, e.g., recall/response biases, especially in cognitively impaired subjects (Crowe et al., 2008; Harada, Chiu, King, & Stewart, 2001; Hauer, Lord et al., 2011). Moreover, they are unable to identify changes or events with temporal precision and intra-individual specificity (Kaye et al., 2011). Also, predictors of LS may operate differently in more global questionnaire data as compared to high resolution data. This is why increasingly objective, technical LS-related assessments (e.g., Global Positioning System, infrared motion sensors, or Bluetooth transmitters; Schenk et al., 2011; Thielke et al., 2014; Tung et al., 2014) are used which also provide a high spatiotemporal resolution of LS not achievable by questionnaire-based assessment. However, such an advanced assessment strategy has so far not been applied in the NH setting. Specifically, a continuous, real-time assessment with high spatiotemporal resolution and minimal intrusion of the daily activities of individuals allows a more accurate picture of LS dynamics in daily ecologies and thus higher ecological validity. It may also become important as an endpoint in intervention research or serve diagnostic purposes by adding information to clinical status assessments.

This study provides a new sensor-based LS assessment in an institutional setting, including automated, high-resolution, spatiotemporal recording of residents' habitual movement behavior within the resident facility across daytime. The aim of this study is threefold: 1) We provide a highly accurate picture of NH residents' LS and movement behavior, not achievable by previously used assessments. 2) Based on the theoretical LS framework of Webber et al. (2010), we examine whether its LS determinants are applicable to the NH setting and allow to develop a model explaining variance in NH residents' LS. 3) Given the unique characteristics of institutions described above, we hypothesize that, in addition to the factors described by Webber et al., a large proportion of the variance in NH residents' LS will be attributable to institutional routines, i.e., scheduled mealtimes.

Methods

Design

The present study is based on cross-sectional data from Long-Term Care in Motion (LTCMo, ISRCTN96090441, Jansen et al., 2014). Ethical approval for the project was obtained from the Ethic Review Board of the Faculty of Behavioral and Cultural Studies at Heidelberg University. The study was conforming to the respective policy and mandates of the Declaration of Helsinki. Either residents or their legal representative provided written informed consent.

Participants

Participant characteristics are presented in Table 6.1. Participants were permanent residents of two comparable NHs in Heidelberg, Germany, that were situated in a quiet, suburban residential area, with promenades and supermarkets close by. The surrounding area was easy to access and did not include mobility barriers such as busy streets or hills. Both homes were obliged to newest care standards, run by the same organization and equal in organizational structures, neighborhood, mealtimes, and activity programs. Their architectural conceptualization was equal, which makes both facilities comparable. Both facilities had long hallways along which the private rooms where located; hallways all met in a large public area where meetings and group activities took place and meals were served; easily accessible elevators and stairs allowed transfer to other units on different building levels. Except for those who were terminally ill or received palliative care, all residents were eligible for participation. Of 259 permanent residents in both NHs, 137 gave consent to participating in the LS assessment, of which 65 fully completed both measurement days. Reasons for exclusion from analysis were removal of sensors ($n = 13$) or incomplete data due to technical difficulties identified via maintenance software running alongside measurement, i.e., reception disturbance or damaging of hardware by NH residents (*n* = 36); measurement interruption due to a power breakdown one morning (*n* = 21); and measurement inaccuracy, i.e., the system could not distinguish between zone 1 and 2 in residents having their private room next to the dining area (*n* = 2).

Table 6.1 Participant Characteristics and Descriptive Statistics on Life-Space Data

	N	Mean (*SD*)	Range
Age [years]	65	82.9 (9.6)	53–98
Sex [female / male]	43 / 22		
Length of stay [years]	65	2.2 (1.7)	0–8
Nursing Home 1 / 2	27 / 38		
Open / code-secured unit	53 / 12		
MMSE [score]	58	18.0 (8.1)	2–30
AES-D [score]	65	15.4 (8.7)	0–28
GDS-12R [score]	56	3.0 (3.3)	0–11
FES-I [score]	55	9.5 (3.2)	7–21
Max. gait speed [m/s]	61	0.57 (0.50)	0–1.99
Ambulatory status	65		
walk without aid	15		
walk with aid	29		
wheelchair, self-propelled	10		
wheelchair, immobile	11		
Time spent in Z1 [h]	65	2.93 (2.33)	0–8
Time spent in Z2 [h]	65	4.30 (2.39)	0–8
Time spent in Z3 [h]	65	0.47 (0.61)	0–2.24
Time spent in Z4 [h]	65	0.31 (0.81)	0–4.13
TAFR [h]	65	5.07 (2.33)	0–8
Transits [n]	65	6.9 (3.2)	0–18

Notes. AES-D = Apathy Evaluation Scale; FES-I = Falls Efficacy Scale International; GDS-12R = Geriatric Depression Scale-Residential; [h] = hours; MMSE = Mini-Mental State Examination; [m/s] = meters per second; [n] = number; TAFR = time spent away from private room; Z = Zone

Data Collection

In order to achieve an advanced descriptive analysis of LS, s-net® technology (Fraunhofer Institute for Integrated Circuits IIS; Wenzel, 2014) was used in both NHs. This technology uses mobile nodes (end nodes) that determine their position at 30 second intervals based on Received Signal Strength Indicator (RSSI) values. RSSI values were calculated based on received messages from wireless communication. An infrastructure of anchor nodes was built within the building as position references for the network's routing function. The anchor nodes were evenly distributed on outside walls at height of approximately 2.3 meters in both NHs, spanning a polygonal area within which end nodes could determine their position (Figure 6.1). To ensure identical density of anchor node distribution in both facilities, 72 anchor nodes were distributed in NH 1 and 151 anchor nodes in NH 2, due to the different size of the buildings. Anchor nodes were configured with fixed positions that were broadcasted periodically during measurement, operating on a transmission frequency of 868 megahertz. End nodes being within broadcast range of anchor nodes received these messages and measured their signal strength. From three to 16 received reference positions of anchor nodes a weighted centroid was calculated, being defined as the estimate of the end node's position. The weights were derived from the measured RSSI values such that the calculated position was closer to the anchor nodes with higher signal strength. The calculations were based on the underlying algorithm (Weighted Centroid Location [WCL]; Blumenthal, Reichenbach, & Timmermann, 2005). RSSI measurements can be severely affected by multipath fading and shadowing on end nodes, resulting in fluctuations of measured values. To address this issue, s-net® localization contains filter components for pre- and post-processing of measured values. Validation of the system showed a mean deviation of 2.28 meters (range: 0.3 - 4.6 meters) of the end nodes' physical position (Wenzel, 2014).

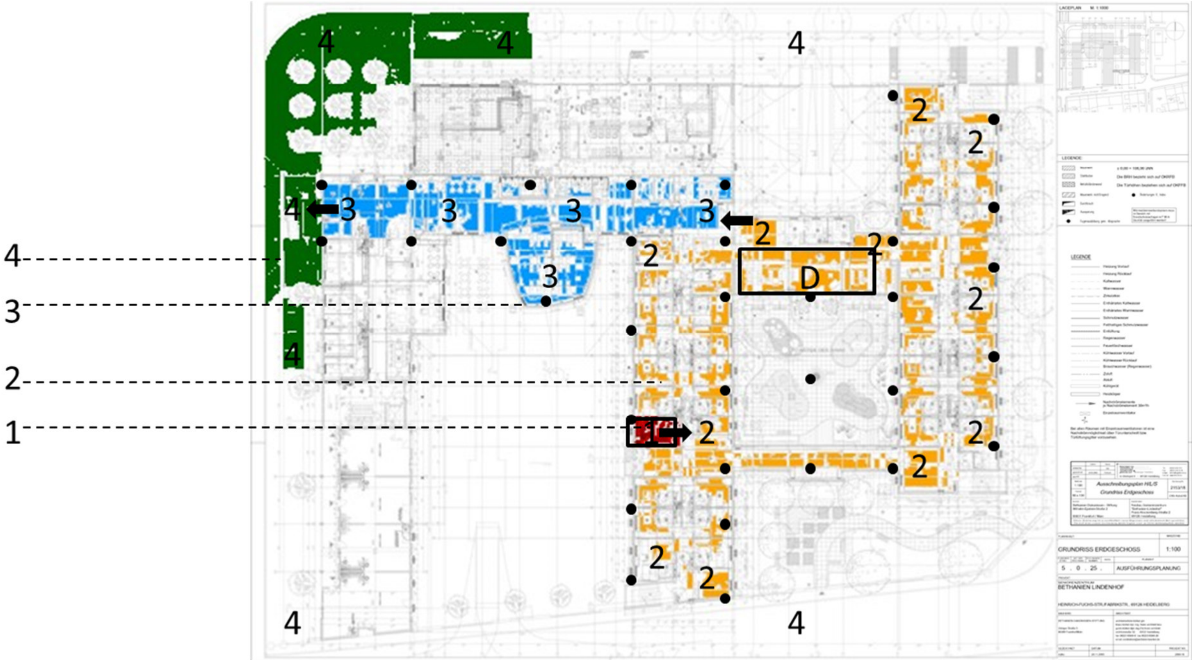
After the system components had been installed in the NHs, the network's connectivity was tested and warranted before measurement started. During the first four measurement days, a Fraunhofer technician monitored communication between sensors using maintenance software that could immediately identify technical problems or failure of single sensors. Due to network capacities, a maximum of 22 participants at a time were equipped with sensors for two consecutive days; the average of both days was used for the analyses. Residents were visited on normal weekdays and equipped with one end node each morning as soon as they left their private room and entered the public dining room. They kept the end node until they returned to their private room in the evening after dinner. To achieve comparability between subjects, LS data were analyzed for each participant from 10 a.m. to 6 p.m. (hereafter referred to as "daytime").

Several steps were taken to control for actual end node wearing time. During measurement, participants were visited every two to three hours to ensure adherence to measurement protocol. In addition, nursing staff were asked to immediately report on lost/found end nodes in order to follow up on reasons for loss or to continue measurement if appropriate. If position reports of end nodes were not received steadily according to maintenance software, end nodes were immediately checked. If participants had not worn end nodes constantly during measurement, they were excluded from analysis. In case of occasional gaps where end nodes were without reception within the network, the duration of these gaps was added to the duration of the preceding episode. This was based on the assumption that an end node is more likely to regain reception as soon as the person wearing it changes her/his location.

Based on previous research (Tinetti & Ginter, 1990), the NH LS was hierarchically structured into four zones (Figure 6.1): private room (Zone 1); outside the room but within the living unit (Zone 2); outside the living unit but within the facility (Zone 3); outside the facility (Zone 4).

Using a previous analytic concept to operationalize LS in community-dwelling persons (Thielke et al., 2014), two LS-parameters were derived from LS raw data to describe relevant behavioral features of residents' spatiotemporal movement in the NH environment: the time residents spent away from their private room (TAFR) and the frequency of LS zone changes (Transits).

Figure 6.1 Overview of one Nursing Home Including the Division of Life-Space Into Four Hierarchical Zones



Notes. Hierarchical zones are delineated as concentric circles as defined by Tinetti & Ginter (1990). Black dots indicate positions of wireless receivers of the measurement system, encasing the whole building; Zone 1 (green) stands for the private room; Zone 2 (blue) stands for the whole living unit in which the private room is located; Zone 3 (orange) stands for the public area outside the living unit but within the facility; Zone 4 (red) delineates the whole area outside the facility. Arrows point out passages between zones. Zone 1 (exemplary private room) is bordered with a black frame. The dining area within Zone 2 is marked with a "D" and bordered with another black frame.

Cognitive Factors. Cognitive Status was assessed using the *Mini-Mental State Examination* (MMSE; Folstein et al., 1975).

Psychosocial Factors. Psychological status was assessed by established assessment methods validated in persons with cognitive impairment or in NH residents (12-item *Geriatric Depression Scale—Residential* (GDS-12R) for depression (Sutcliffe et al., 2000), *Apathy Evaluation Scale* (AES-D; Lueken et al., 2006; Lueken et al., 2007; Marin, Biedrzycki, & Firinciogullari, 1991) for apathy, and the *Short Falls Efficacy Scale International* (Short FES-I; Hauer, Kempen et al., 2011; Yardley et al., 2005) for fall-related self-efficacy (Hauer et al., 2010).

Environmental Factors. TAFR and Transits during institutionally scheduled mealtimes—including 15 minutes transfer time before and after—were extracted to operationalize institutional routines. Unscheduled LS was defined as TAFR and Transits during the rest of the daytime. In total, institutionally scheduled mealtimes constitute 2.7h of the overall measured daytime (8.0h).

Physical Factors. Based on observations and staff information, residents were rated regarding their *ambulatory status* as *(a)* ambulatory without aid, *(b)* ambulatory with aid, *(c)* self-propelled wheelchair user, and *(d)* fully immobile wheelchair user. Gait speed was assessed with a *10m walk test* at maximum walking speed, using a walking aid if necessary.

Socio-Demographic Factors. Age, sex, and length of stay in the facility were assessed using the care documentation.

Data Analysis

Descriptive LS analysis included mean, standard deviation, and range for all variables. Relative strength of associations between LS measures (TAFR and Transits; average of both measurement days) and independent variables were determined by linear regression models. Variables were considered for inclusion into the regression models based on structural coherence with the dimensions described in the LS mobility framework by Webber et al. (2010), except for financial factors which, as we assume, play no role in our sample. Given our rather small sample size, predictors that were not correlated with the criterion variables (bivariate correlations of either r or $rho < .2$ and $p > .10$; Table 6.2) were not included in the models; only one factor was included for each dimension. To avoid multicollinearity in case of several factors of the same domain being correlated to dependent variables, these were included separately in the regression models and the strongest factor was then selected. To explore the association between institutional routines and LS, we repeated the regression analysis but controlled for the variance of Transits and TAFR during institutionally scheduled mealtimes. Regressions were based on full information maximum-likelihood (FIML) estimations which consider all available data from all respondents, thus avoiding selective case deletion and maintaining sample size-dependent power. FIML provides unbiased estimations given that data were missing at random and multivariate normal (Schafer & Graham, 2002). To account for non-normality, we used a robust maximum likelihood estimator. Dependent t-tests for paired samples were computed to analyze differences between LS during institutionally scheduled mealtimes and unscheduled daytime. All statistical analyses were performed using SPSS for Windows (IBM Corp., Released 2014) and Mplus version 7.31 (Muthén & Muthén, 1998–2012).

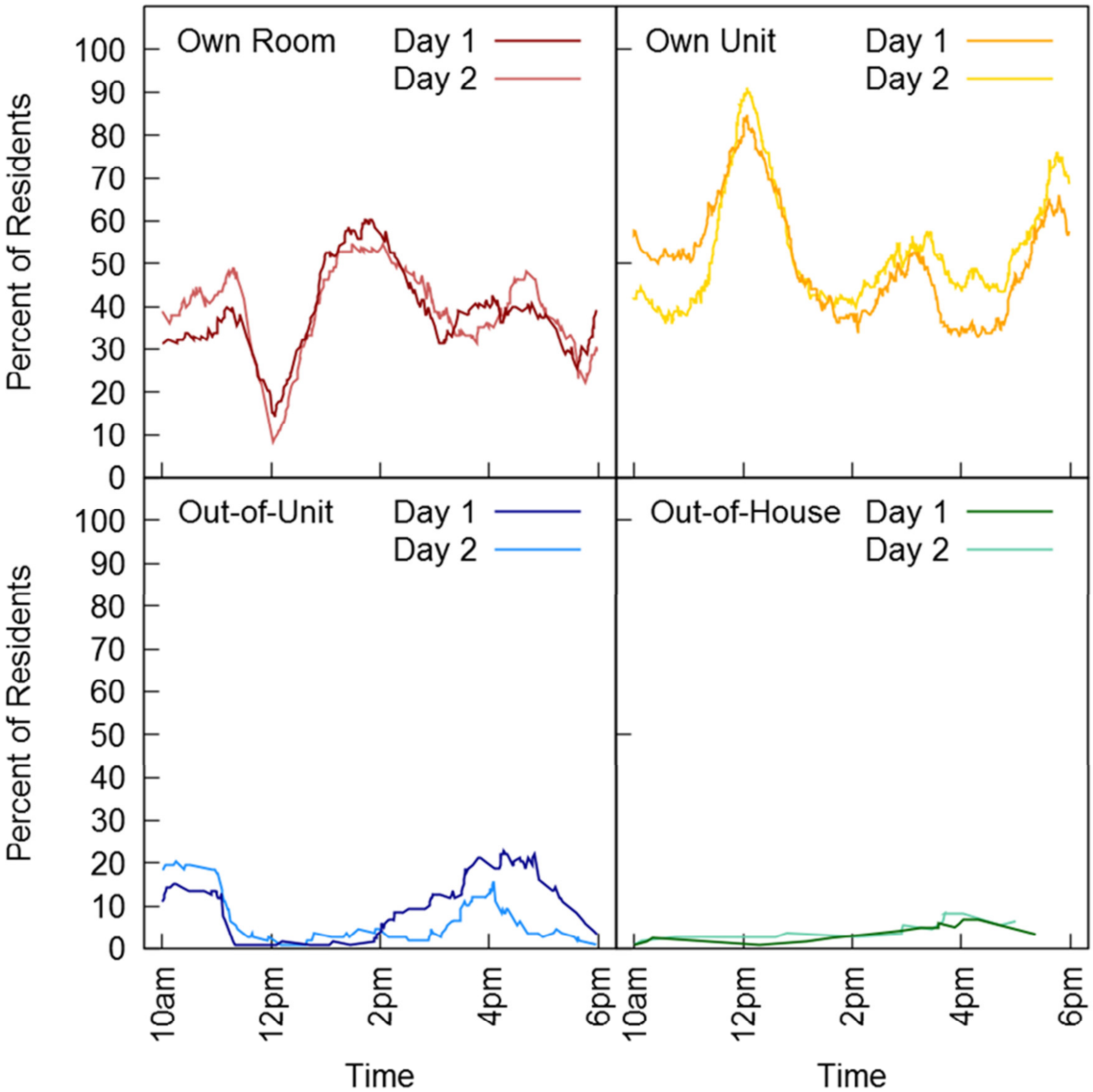
Results

Descriptive Life-Space Statistics

According to the s-net® measurement protocol, approximately 62,400 position reports were received during the study, which is equal to 480 observations of each NH residents's position per day [62,400 / (65 NH residents × 2 days)]. Results of the LS measures TAFR, Transits, and the average duration of stay in the four LS-zones (displayed in Table 6.1) on both days show that LS of residents was to a very large extent restricted to the private room (zone 1: 2.93h = 36.6% of the daytime) and the immediate area around it (zone 2: 4,30h = 53,8%). On average, NH residents spent only 0.47h (= 5.9%) outside the own unit but within the facility (zone 3) and only 0.31h (= 3.8%) outside the facility (zone 4) per day. Three quarters of the residents went beyond their living unit and one quarter left the facility at least once during both measurement days. On average, almost seven Transits (6.9 ± 3.2; Range: 0–18) were made. Only two residents (3.1%) never left their room whereas 22 residents (33.8%) spent less than one hour in their room during daytime. Intraclass Correlation Coefficients (ICCs) showed fair agreement between both measurement days for Transits (.41) and strong agreement for TAFR (.76).

Figure 6.2 shows residents' LS with spatial *and* temporal resolution, i.e., the percentage of residents measured in each LS zone across the daytime.

Figure 6.2 Percentage of Nursing Home Residents in Each of the Life-Space Zones Across Two Measurement Days



Notes. Most resident Transits occurred during lunch time between 11.30 a.m. and 1.00 p.m. and during dinner time around 5.20 p.m. and 6.00 p.m. The only time frames in which several residents left their own living unit were between 10 a.m. and lunch and between 2 p.m. and dinner. The highest number of residents (8%) was located outside the facility around 4 p.m..

Predictors of Life-Space in Nursing Home Residents

Results of bivariate correlation analysis are presented in Table 6.2; results of linear regression analyses in Table 6.3. Male sex, lower gait speed, lower apathy, and higher cognitive status were associated with higher amounts of Transits and jointly accounted for 27% of the variance ($p = .002$). Apathy and cognitive status, however, were not significant in the regression model.

Table 6.2 Bivariate Correlations between Life-Space Measures and Predictor Variables

	TAFR	Transits
Age [yr]	-.10	-.15
Sex	-.07‡	.36**‡
Length of Stay [yr]	.01	.08
MMSE [score]	-.47***	.34**
Gait Speed [m/s]	.51***	-.28+
GDS-12R [score]	-.35**	.15
FES-I [score]	-.36**	.28*
AES-D [score]	.09	-.28*
Ambulatory Status	.08‡	.13‡

Notes. AES-D = Apathy Evaluation Scale; FES-I = Falls Efficacy Scale International; GDS-12R = Geriatric Depression Scale-Residential; MMSE = Mini-Mental State Examination; TAFR = time spent away from private room; † = Pearson *r*; ‡ = Spearman rho; +$p < .10$; *$p < .05$; **$p < .01$; ***$p \leq .001$

Table 6.3 Linear Regression Analyses—Models for Transits and Time Away From Room

Transits	β	SE	Sβ
Sex	3.02**	1.03	.34**
Gait Speed	-2.27*	1.14	-.21*
AES-D	-0.10	0.07	-.21
MMSE	0.07	1.14	.13
R^2			.27**
TAFR			
Gait Speed	2.34***	0.61	.38***
MMSE	-0.10***	0.03	-.36***
GDS-12R	-0.14*	0.07	-.20*
R^2			.43***

Notes. β = raw β; R^2 = overall R^2 of each model; Sβ = standardized β; SE = standard error; AES-D = Apathy Evaluation Scale; GDS-12R = Geriatric Depression Scale-Residential; MMSE = Mini-Mental State Examination; TAFR = time spent away from private room; +$p < .10$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

In the model for TAFR, higher gait speed, lower cognitive status and fewer depressive symptoms were significantly associated with more TAFR. The model accounted for 43% of the variance ($p < .001$). Although concerns about falling were significantly correlated with TAFR, Short FES-I scores were not included in the final model as they explained less of the variance than GDS scores and did not contribute more to the overall variance explanation of the model.

Life-Space and Institutional Routines

When subsequently included in the models, TAFR and Transits during institutionally scheduled mealtimes showed a very strong effect on overall TAFR and Transits. TAFR during these explained almost 80% of the variance of the overall TAFR ($R^2 = .80$, $\beta = 2.83$; $p < .001$), leaving all other predictors insignificant. A similar effect was observed for Transits ($R^2 = .67$, $\beta = 1.78$; $p < .001$). During institutionally scheduled mealtimes, residents spent significantly more TAFR per hour than during unscheduled daytime (70.0% vs. 59.8%, $t = 4.24$, $p < .001$) and performed more Transits per hour (1.58 vs. 0.69, $t = 11.35$, $p < .001$).

Discussion

To the best of our knowledge, this is the first study to explore LS in NH residents based on objective, sensor-based assessment with a high spatiotemporal resolution. Key findings of the current study were that 1) LS was very limited in NH residents; 2) factors belonging to dimensions included in the framework by Webber et al. (2010) are also applicable to the NH setting; 3) when included in the models, the strongest association was found between overall LS variables and institutionally scheduled routines such as mealtimes.

Following the methodological paths of key studies in the field of LS research (Baker et al., 2003; May et al., 1985; Stalvey et al., 1999; Tinetti & Ginter, 1990), we took a different practical approach by using a sensor-based system to obtain a comprehensive and objective picture of LS in NH residents. Unlike subjective assessments used in previous studies, our objective assessment approach is not limited to generating a composite LS score, but also provides data on the chronological order in which LS areas where visited and for how long. This allows investigating LS far more extensively than before, including aspects of daily movement behavior in a sample of highly vulnerable NH residents with high prevalence of advanced motor and cognitive impairment.

Despite the rather tight corset of the daily structure in institutions like NHs, data analysis revealed a wide spectrum of LS, ranging from residents who permanently stayed in their private room to those who were permanently absent from their room during daytime (see Table 6.1). Due to the lack of LS-related research in the NH setting, there are no results available for comparison with our findings on the duration a subject spent at a certain room or the frequency in which s/he changed zones on a daily basis in NH residents. Results from studies using the NHLSD (Mortenson et al., 2012; Tinetti & Ginter, 1990) are hardly comparable as this measure is conceptualized as composite LS score regarding the past two weeks. When compared to independent-living seniors, NH residents perform considerably less Transits (6.9 per day vs. 10.8 room changes per hour) and spent muss less time out of the house (0.3 hours per day vs. 4.0 hours per day; Thielke et al., 2014). It has to be taken into account that in these two groups, the different LS zones have a different connotation, e.g., TAFR for a NH residents still means staying indoors, whereas time away from home for an independent-living subject means leaving the building.

Our data show that the main part of NH residents' daily life unfolded on the living units. Only very few individuals left their unit or facility and thus were not engaged in any activity beyond the facility at all. This is in line with Goffman (1961), who pointed out that institutions such as NHs are characterized by a "barrier to social intercourse with the outside" (p. 4). Some NH residents may be worried by the thought of entering a less controlled, rather unknown and unsafe area beyond their unit. Others may feel drawn out of isolation in their room toward more eventful places. As a result, most NH residents mainly stay in the public areas of their living units—a behavior which may also be attributable to motor and cognitive impairment of NH residents.

Results from linear regression analyses confirm the LS-related dimensions identified by Webber et al. (2010) in their framework as well as findings in previous studies (Baker et al., 2003; Barnes et al., 2007; May et al., 1985; Simmons et al., 1995; Tung et al., 2014; Uemura et al., 2013). In line with previous studies that found male sex being associated with larger LS mobility (Al Snih et al., 2012; Peel et al., 2005), male sex was associated with more Transits in our sample.

Regarding motor performance, we found conflicting results on the association between LS and gait speed. Whereas more TAFR was associated with higher gait speed, more Transits were associated with lower gait speed. Thus, residents with better walking abilities change LS areas less frequently but stay in zones 2 to 4 for longer periods of time. One explanation may be that NH residents with inferior walking abilities and functional capacity need to take rest periods in their private rooms more frequently than those with better physical function. We see this contrasting association of functional performance with both LS parameters as an indicator of different underlying concepts of both parameters requiring further investigation.

Our finding that lower cognitive status and fewer depressive symptoms were associated with TAFR finds support in results on community-dwelling subjects regarding the time out of home (Sartori et al., 2012; Thielke et al., 2014). Lower cognitive status was associated with more TAFR and less Transits in our sample. Cognitively impaired subjects probably feel drawn to public areas due to certain aspects of these areas that draw attention (e.g., noise or conversation; Algase et al., 1996). Due to diminished wayfinding abilities (i.e., not finding their own private room and staying where they presently are instead), or a high prevalence of apathy, they are often bound to stay in such public areas or other already determined locations. Cognitive performance may also reflect staffs' reaction to these symptoms of dementia, that is, to keep residents in sight in the public area, and thus a larger amount of time is spent in public areas away from the own room, and less Transits are performed (Kuhn, Kasayka, & Lechner, 2002). However, beta weights were not significant for MMSE scores in the Transits regression model. The same applies to beta weights for apathy, with lower apathy being associated with more Transits, as previously reported in community-dwelling subjects (Tung et al., 2014). To explore this insignificance, we examined these linear regression results more closely. We found that AES-D scores were significantly correlated with MMSE scores (Pearson's $r = -.558$; $p < .001$). When eliminating one of both measures from the regression model, the other factor became significant (AES-D: $S\beta = -.280$; $p = .005$; MMSE: $S\beta = .253$; $p = .045$), indicating that AES-D and MMSE have a considerable proportion of shared variance explanation. This is not surprising as apathy is a key symptom of dementia (Aalten et al., 2008).

As expected, the strong association between institutional factors and LS became very clear. When controlling for the variance of Transits and TAFR during institutionally scheduled mealtimes in separate models, it explained 67% (Transits) and 80% (TAFR) of the variance of Transits and TAFR during overall daytime, even though it only stood for one third of the overall measurement time. In the presence of these control variables, all other predictors included in the final models became insignificant, which demonstrates the high association between the variance of LS parameters during mealtimes and overall variance, adding valuable information regarding the structure of the Webber et al. framework when applied in the NH setting. That is, when comparing institutionally scheduled mealtimes with unscheduled daytime, considerable differences in LS parameters were found. During institutionally scheduled mealtimes, there were twice as many Transits per hour and TAFR was more than 20% higher. This has several implications: First, institutionally scheduled time is a rather "active" time, as it requires the majority of otherwise rather sedentary residents to move (or be moved) to the dining area and to be around others in a social context. Compared to this active time, NH residents actually tend to be less active when they can freely decide what to do, e.g., participate in optional social group activities. Second, it implies a restriction of LS in terms of its *range*, as NH residents have to be *inside* and *within* the living units during these institutionally scheduled mealtimes if they want to be served their meal—unless they are invited and picked up for a meal by friends or relatives.

Several limitations of the study have to be noted. Although the sensor-based assessment provides an objective documentation of LS, this technological approach comes with some technical limitations, especially regarding gaps in data transmission. Due to the systems localization frequency of one per 30 seconds, Transits within this time frame could have been missed if more than one had occurred. However, due to the low gait speed and motor function of our sample, more than one Transit within 30 seconds is a rather unlikely event. As a relatively high number of participants had to be excluded from analyses, the study sample was limited and thus potentially underpowered for certain research questions. Some of the independent variables are based on self-report measures, which may have been affected by recall and response bias due to cognitive impairment or other factors such as depressive symptoms. The study design was intentionally inclusive, also including a minor group of persons being unable to move independently. However, we see LS as an objective reality, irrespective of its active or passive occurrence.

Some valuable practical implications arose from our study. With a view to the associated factors found in this study, and by identifying the individual movement patterns of each resident during the day, our assessment approach may also be suitable for documenting deterioration in motor function and development of depression or behavioral symptoms related to dementia such as apathy (manifesting as 'never leaving the private room') or wandering/restlessness (manifesting as 'moving around constantly'). The fact that NH residents are particularly inactive between meals shows the good occasion in the daily schedule for implementing physical activity and LS enhancing interventions. These should be focused on associated factors that are susceptible to intervention (especially gait, apathy, and depressive symptoms), and be carried out on the living units in order to be within reach of the majority of residents who do not go beyond their living unit. Overall, the sensor-based LS assessment is a good example of how new assessment strategies may provide new and more comprehensive insights into the movement behavior of NH residents. As it is still undergoing further development, the sensor-based LS assessment promises to capture more complex parameters that may be derived from raw data in the future, e.g., distance travelled within the facility as a measure of physical activity. Our approach may also help in identifying architectural and environmental characteristics of NHs such as dangerous, fall-provoking spots or important meeting places, and unfrequented, deserted areas in the facility, allowing enrichment of the environment and further stimulation of NH residents' social participation in daily life.

Conclusions

As derived from a sensor-based measurement for indoor localization, the LS of NH residents was mainly limited to private rooms and living units. The LS framework by Webber et al. has proven useful in the NH setting as LS was associated with predictors similar to those previously identified in studies with community-dwelling subjects. However, it requires modification in that daily routines such as meal times should be included as a determinant in institutional settings due to their high impact on residents' LS as revealed in regression models. Gait speed, apathy, and depressive symptoms as well as institutional meal routines were the only modifiable predictors of Transits and/or TAFR, and thus have the potential to lead to an enhancement of NH residents LS and movement behavior when targeted with interventions.

Abbreviations

β: beta weight; AES-D: Apathy Evaluation Scale; FES-I: Falls Efficacy Scale International; FIML: Full Information Maximum-Likelihood; GDS-12R: Geriatric Depression Scale-Residential; LS: Life-space; MMSE: Mini-Mental State Examination; [m/s]: meters per second; *n*: group size; NH: nursing home; NHLSD: Nursing Home Life Space Diameter; *p*: significance level; *r*: Pearson's *r*; rho: Spearman's rho; RSSI: Received Signal Strength Indicator; *SD*: standard deviation; Sβ: standardized beta weight; TAFR: time spent away from the private room

Declarations

Ethics Approval and Consent to Participate

Ethical approval for the project was obtained from the Ethic Review Board of the Faculty of Behavioral and Cultural Studies at Heidelberg University. Either residents or their legal representative provided written informed consent.

Consent for Publication

Not applicable.

Availability of Data and Material

The raw data are available by email on reasonable request to Carl-Philipp Jansen (corresponding author). E-mail: carl-philipp.jansen@psychologie.uni-heidelberg.de

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

HWW, KH: study concept and design. CPJ, MD, ELS: study organization and data acquisition. CPJ, MD, HWW, KH: analysis and interpretation of data. CPJ, MD, ELS, HWW, KH: preparation and revision of manuscript. All authors read and approved the final manuscript.

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7

General Discussion

7.1 General Discussion

The focus of this dissertation was to examine the association of depressive symptoms with residents' functional competencies and social activities; the potential of a physical activity-enhancing intervention, and the role of social activity enjoyability. To also address potential outcomes of depressive symptoms, the predictive value of depressive symptoms for residents' sensor-based life-space was also examined. In the following sections, this dissertation's findings with respect to each of these issues will be presented, the role of cognitive impairment will be discussed, and limitations and strengths will be revealed. Finally, implications for future research and gerontological practice will be considered.

7.1.1 Important Linkages between Everyday Competence and Depressive Symptoms

While most NH research on depressive symptoms considered either BaCo (e.g., Drageset, Eide, & Ranhoff, 2011; Kaup et al., 2007) or ExCo (e.g., Cheng et al., 2010; Park, 2009), Study I showed, consistent with hypothesis Ia (see Table 1.2), the relevance of independent BaCo and ExCo factors for depressive symptoms. It further suggests that other model-proposed factors (e.g., cognitive disability, sex, age) were non-significant predictors cross-sectionally when BaCo and ExCo were in the model. It also showed that BaCo impairment affected residents' depressive symptoms cross-sectionally via a perceived loss of control, as expected in hypothesis Ib, while ExCo affected residents' depressive symptoms directly—a result which did not conform to hypothesis Ib. However, the association between BaCo impairment and depressive symptoms holds for ambulatory residents only because performance-based data were not available for non-ambulant residents who, thus, had missing values on their BaCo variables.

These results seem to reflect specificities of the NH ecology. For example, the non-significant correlation between BaCo and ExCo appears to be surprising because BaCo and ExCo were correlated in previous research (Baltes et al., 2001). Taking a closer look, however, the non-significant correlation might either be a methodological artifact or may result from the substantial independence of BaCo and ExCo in the NH. In the former case, the different acquisition modes (performance-based or proxy rating) used in

Study I may share less common variance than the interview-based measures ([I]ADL appraisal, yesterday interview, activities during last year) used by Baltes et al. (2001). This lack of shared variance between BaCo and ExCo might then have caused the non-significant correlation and would not allow a substantial conclusion about BaCo's real-life relation to ExCo. However, the fact that the measures of BaCo and ExCo used in Study I did not rely on resident's appraisal may support the alternative explanation of substantially different and independent BaCo and ExCo factors in NH residents. Consequently, the non-significant correlation could hint at the possibility of experiencing positive reinforcement in spite of physical disability, which may be due to staff enabling physically-impaired residents to participate in social activities. Conversely, the non-significant correlation could also hint at the possibility of experiencing reduced positive reinforcement despite being in control of basic daily activities in the NH, which might in turn be due to residents' self-determined refusal to participate.

This reasoning of a substantial independence of BaCo from ExCo might also explain why BaCo but not ExCo was mediated by perceived control. BaCo may determine how well a resident gets along in daily life NH and how much of a feeling of control s/he gains from mastering such daily activities. For ExCo, however, staff may compensate for BaCo impairments and allow residents to participate in ExCo-related activities, irrespective of their BaCo or control perception. These considerations also led to the assumption of an additional direct association between everyday competence and reduced positive reinforcement (see Figure 1.2), which was examined in Study III.

Considering the theoretical model of depressive symptoms in the NH, which suggests intra-individual associations between changes in everyday competence, consequent changes in perceived control, and changes in depressive symptoms (Meeks & Depp, 2003), Study I answered the question of how the constructs are related inter-individually at a given moment in time. Although this can be seen as an important insight, the proposed longitudinal associations could not be tested in Study I. Hence, Studies II and III served this as well as additional purposes to this end.

7.1.2 Effects of a Physical Activity Program on Depressive Symptoms

Study II elaborated the theoretical and empirical background for why LTCMo is assumed to counteract the expected increase in residents' depressive symptoms over time and also focused on the respective training effects. Hypothesis IIa of a naturally occurring increase in depressive symptoms across nine months was confirmed (Nat-CG trajectory). Study II also showed, as expected in hypothesis IIb, the malleability of this development as participating in the PA program was associated with stabilizing depressive symptoms at pre-intervention level whereas not participating in the program was associated with increasing depressive symptoms. The PA-IG had significantly fewer depressive symptoms than the Nat-CG at post-intervention and at follow-up, and this finding remained stable when controlling for NH site, sex, age, living on dementia-care floor, perceived vision, and perceived internal and external control (see also Study I). Importantly, antidepressant medication according to ATC code N06A did not predict training participation and shall, therefore, neither have influenced the training effects. In view of previous well-designed RCTs that did not find a significant effect of exercise in terms of reducing residents' depressive symptoms (e.g., Chin A Paw et al., 2004; Rolland et al., 2007; Underwood et al., 2013), the effect of LTCMo's PA promotion program is remarkable but also requires additional explanation. For example, the training program's effectiveness regarding residents' depressive symptoms might be due to the rather homogeneous groups who received an intensive training tailored to individual competences and the involvement of well-educated NH activity coordinators who implemented the training sustainably in their NHs. Additionally, state-of-the-art analysis methodology (GLMM) was used, which may exploit training data better than traditional methods (such as ANOVAs or *t*-tests) with respect to power and direct testing of the intervention effects. However, future research is needed to empirically investigate the driving forces behind the effect as well as the interplay of these driving forces. For now, the results may be promising but deserve further validation before practical implications are warranted.

7.1.3 Linkages between Frequency and Enjoyability of Expanded Everyday Activities and Residents' Depressive Symptoms

Study III built on the relevance of ExCo-related activities for residents' depressive symptoms (Study I) and considered the role of activity enjoyability across up to four time points. As expected in hypotheses IIIa–c, differential associations were confirmed between the ExCo domains self-initiated contact with co-residents or care staff and participation in in-home activities and residents' depressive symptoms. For co-resident contact, frequency moderated, as expected in hypothesis IIIa, the effect of enjoyability with fewest depressive symptoms for residents who frequently initiated enjoyable co-resident contact. For staff contact, both self-initiated contact and its enjoyability were marginally associated with fewer depressive symptoms. However, the expected effect of enjoyability was not found (hypothesis IIIb). For activity participation, participation enjoyability but not frequency was associated with fewer depressive symptoms, which was consistent with hypothesis IIIc. Additionally, the results showed that training participants revealed fewer depressive symptoms than non-participants after the training across all studied ExCo-related domains—adding to the robustness of Study II results (see also hypothesis IIb).

Study III thus showed the relevance of considering ExCo-related activity enjoyability alongside frequency with respect to depressive symptoms. It also showed the relevance of differentiating these associations by ExCo-related activities, which may add to the basic understanding of assumptions behind pleasant events-based interventions.

7.1.4 Associations between Depressive Symptoms and Residents' Objectively Measured Life-Space

Study IV described residents' sensor-measured LS throughout the day and showed that it was rather small and strongly related to institutional routines. It also showed, conforming to hypothesis IV, that more depressive symptoms in the NH are associated with reduced LS, namely with less time spent outside the own room. This may indicate model-implied reduced activity as a consequence of depressive symptoms (Meeks & Depp, 2003), but may likewise reflect depressive symptoms such as a loss of energy or a loss of interest (American Psychiatric Association, 2013).

The study further allowed a glimpse into the association between depressive symptoms and behavioral variability. Following the idea of optimal movement variability (Stergiou, Harbourne, & Cavanaugh, 2006) and considering the depressive symptoms of motor retardation, loss of energy, and loss of interest (American Psychiatric Association, 2013), one might assume that depressive symptoms are associated with lower than average LS variability. However, residents' depressive symptoms were not significantly associated with the number of transits, that is, depressive symptoms could not explain inter-individual differences in the number of transits (Study IV). Still, future research may investigate the association considering non-linear associations (as might result from depressive symptoms-related motor agitation) and a higher resolution of spatiotemporal LS data (Study IV considered LS zone changes rather than room changes, for example).

However, the present analyses did not address associations between depressive symptoms and spatiotemporal LS patterns. Therefore, future research may address the question of whether depressive symptoms-specific circadian rhythm disturbances (Germain & Kupfer, 2008) are reflected in depressive symptoms-related LS patterns throughout the day. For example, residents suffering from depressive symptoms may have spent more time in their own rooms in the morning compared to residents suffering from fewer depressive symptoms.

7.2 The Role of Cognitive Impairment

As noted in the introduction, one peculiarity of the NH setting is the high rate of cognitively impaired residents living there (Hoffmann et al., 2014; Schäufele, Köhler, Hendlmeier, Hoell, & Weyerer, 2013). Because cognitive impairment may hamper data collection, the reliability of interview-based data will be discussed regarding residents' cognitive impairment. Furthermore, a synopsis of the role of cognitive impairment in the presented studies will be provided. As no clinical diagnosis of dementia as gold standard was available in the present study, cognitive impairment was operationalized using a NH-specific cut-off point on the Mini-Mental State Examination (MMSE; Folstein et al., 1975; Paquay et al., 2007).

7.2.1 Interview Data and Cognitively Impaired Residents

LTCMo strived to include *all* residents who opted to participate, which is why I aimed at including cognitively impaired residents in the analyses, too. This would allow studying a sample more representative of the NH population, which would maintain as high a level of ecological validity for the results as possible given our sample. Following this line of argument, I faced the dilemma as to whether cognitively impaired residents should be included or excluded. The former would imply accepting a potentially reduced reliability of the data for cognitively impaired residents; the latter would imply accepting a potentially biased sample of selected cognitively fit residents which would not allow drawing conclusions for the whole sample. The reasoning behind dealing with data from cognitively impaired residents was as follows:

To enhance assessment reliability at the data-generational level, research assistants were trained in interview techniques with NH residents, especially in dealing with cognitively impaired individuals' potential answering behavior (see Chapter 2.4). To investigate assessment reliability, additional data analyses were run for the GDS-12R as well as other interview data. With respect to depressive symptoms, the GDS has been validated in older adults including persons with mild-to-moderate cognitive impairment (Conradsson et al., 2013). However, research on using GDS versions in cognitively impaired NH residents yielded inconsistent results regarding differences in sensitivity and specificity between cognitively impaired versus unimpaired residents (McGivney, Mulvihill, & Taylor, 1994; Mitchell, Bird, Rizzo, & Meader, 2010; Parmelee et al., 1989). The Study I sample was used to investigate the role of cognitive impairment in residents' answering behavior. Of the 196 residents included, 67% answered the GDS-12R. Following the recommendations of a validation study in NHs that used the Cambridge Examination for Mental Disorders of the Elderly–Revised (CAMDEX-R) as reference standard (Paquay et al., 2007; Roth et al., 1986), residents with MMSE $\leq$ 19 were considered as cognitively impaired, but residents with MMSE > 19 as not cognitively impaired. Table 7.1 shows the number of valid answers on each GDS-12R item as well as the missing data rate by cognitive impairment.

Table 7.1 Missing Data Rates for GDS-12R Items by Cognitive Impairment

	GDS_1	GDS_2	GDS_3	GDS_4	GDS_5	GDS_6	GDS_7	GDS_8	GDS_{11}	GDS_{12}	GDS_{13}	GDS_{14}	GDS-12R
n(MMSE ≤ 19)	53	52	53	55	53	52	53	54	51	54	52	51	55
n(MMSE > 19)	70	71	70	71	67	71	62	69	68	68	69	68	72
Missing Rate(MMSE ≤ 19)	4	5	4	0	4	5	4	2	7	2	5	7	0
Missing Rate(MMSE > 19)	3	1	3	1	7	1	14	4	6	6	4	6	0

Notes. Only data of individuals who answered the MMSE and could thus be categorized as cognitively (un-) impaired are displayed; only data of individuals who also answered the GDS-12R are displayed; n = 127.

Notably, GDS_7 ("Do you feel happy most of the time?") shows a considerably higher rate of missing data for cognitively fit compared to impaired residents. This high missing rate might indicate that cognitively fit residents had some difficulty answering this question. Across other items, the missing data rate was comparably high for cognitively impaired and unimpaired residents, which supports the notion that residents could validly answer the items irrespective of their cognitive impairment. Further support for the reliability of the answers given comes from additional analyses: The GDS-12R's internal consistencies were equally high for the cognitively impaired vs. unimpaired group (α = .85 and .81, respectively), which is consistent with previous research (Parmelee et al., 1989; Sutcliffe et al., 2000). When cognitive status as measured by the Dementia Screening Scale (DSS; Köhler et al., 2007) was considered as a covariate in Study I, it did not predict depressive symptoms at the latent level (p > .05). Moreover, the scale proved to be strongly invariant across the cognitive impairment groups ($\chi^2_{\text{scalar invariance - configural invariance}}(10) = 10.38$, p > .05).

Concerning other interview data (namely, perceived control, activity enjoyability, and perceived vision), psychometric properties for cognitively impaired residents are largely unknown. For example, cognitively impaired older adults were excluded in developing and validating the perceived control items and the pleasant events schedule—NH version (Kovaleva et al., 2012; Meeks et al., 2009). Using Study I data again, Table 7.2 shows the number of valid answers on each item as well as the missing data rate by cognitive impairment (MMSE ≤ 19 vs. > 19).

Table 7.2 Missing Data Rates for Other Interview Items by Cognitive Impairment

	Internal Control$_1$	*Internal Control$_2$*	*External Control$_1$*	*External Control$_2$*	Internal Control	External Control	*Enjoys Resident Contact*	*Enjoys Staff Contact*	*Enjoys Participating*	*Perceived Vision*
n(MMSE ≤ 19)	49	48	47	44	46	42	52	50	51	53
n(MMSE > 19)	69	67	69	67	66	66	69	68	71	71
Missing Rate(MMSE ≤ 19)	11	13	15	20	16	24	5	9	7	4
Missing Rate(MMSE > 19)	4	7	4	7	8	8	4	6	1	1

Notes. Only data of individuals who answered the MMSE and could thus be categorized as cognitively (un-) impaired are displayed; only data of individuals who also answered the GDS-12R are displayed; n = 127.

Across all items, the missing data rate was higher for cognitively impaired residents, which supports the notion that residents too impaired to validly answer the items were excluded due to showing too many missing items. Furthermore, the latent perceived control variable used in Study I proved to be invariant across the cognitive impairment groups ($\chi^2_{\text{scalar invariance - configural invariance}}(14) = 22.17$, $p > .05$), which supports the reliability of the answers given.

Striving to keep the sample as representative of the NH population as possible and encouraged by the analyses, which uniformly suggested equally high measurement reliability for cognitively impaired and unimpaired residents, the decision was made to keep cognitively impaired residents in the analyses presented here.

7.2.2 The Role of Cognitive Impairment in the Studied Associations with Depressive Symptoms

Three proxy variables for residents' cognitive status were available, namely the DSS (Köhler et al., 2007), the MMSE (Folstein et al., 1975), and a variable indicating living on a dementia care unit. Using pretest data, all three significantly correlated with residents' depressive symptoms (r = -.22, p < .05; r = .26, p < .01; r = -.20, p < .05, respectively). Notably, the DSS is based on proxy ratings, the MMSE on residents' performance, and the unit indicator differs from the other two as it is located on the institutional rather than the individual level. Residents with dementia could live outside a dementia care unit and residents with challenging behaviors unrelated to dementia could live in a dementia care unit.

Proxy-rated cognitive impairment as measured by the DSS did not significantly affect residents' depressive symptoms at the level of latent variables (Study I; standardized path coefficient = -.08, $p > .05$; data not shown). Furthermore, residents' latent cognitive impairment variable neither significantly correlated with the latent BaCo variable, the latent ExCo variable, nor with residents' sex (all $p > .05$; data not shown). The only model-relevant variable that the latent DSS variable significantly correlated with was calendar age ($r = .26$, $p < .01$; data not shown). As the cognitive impairment factor was based on six rather than seven items due to the high rate of missing data on DSS_7, the DSS could neither be calculated as intended nor could the cut-off be applied to categorize residents as cognitively impaired vs. unimpaired. Therefore, in the analyses presented below, residents' MMSE scores were used to estimate their cognitive status based on manifest rather than latent variables.

According to the MMSE cut-off for the detection of cognitive impairment in NH residents (MMSE ≤ 19; Paquay et al., 2007), 55% of training and 39% of non-training residents were cognitively impaired. As illustrated in Study II (Table 4.1), a group training was implemented that was specifically designed for residents on a dementia care unit. Therefore, it was necessary to control for living on a dementia care unit as a proxy variable for dementia in examining the training effects. Because this variable showed significant point biserial correlations with residents' MMSE scores ($r = -.47$, $p < .001$ at pretest), I refrained from controlling both variables. However, when Study II analyses were re-run controlling for MMSE rather than living on a dementia care unit, the result pattern remained unchanged with a significant training effect and a marginally significant effect of residents' cognitive status (see Table 4.3).

When ExCo-related activity and frequency were focused as predicting residents' depressive symptoms (Study III), MMSE scores predicted significantly more depressive symptoms across all ExCo domains considered (all $p < .001$, see Table 5.3). However, the effects of cognitive impairment on residents' depressive symptoms were small. Finally, when depressive symptoms were considered alongside MMSE-based cognitive impairment and BaCo-related gait speed, all three significantly predicted residents' LS

(Study IV, see Table 6.3). This finding may hint at the independence of depressive symptoms and cognitive impairment in predicting LS.

To summarize, though cognitive impairment at pretest was associated with significantly fewer depressive symptoms, the effect in predicting residents' depressive symptoms turned out to be very small or non-significant when other variables were considered. Stated differently, cognitive impairment effects were rendered non-significant or close to zero when all other predictor effects were partialled out, which may suggest that the focused predictor variables are more able to explain residents' depressive symptoms than cognitive impairment (e.g., M3 in Table 4.3, Study II; all models in Table 5.3, Study III). Therefore, cognitive impairment was named rather than discussed and BaCo, ExCo, and ExCo-related enjoyability were focused on in Studies I–IV.

7.3 Limitations and Strengths

Limitations were already extensively discussed in the papers: These are, mainly, the use of a dimensional scale of depressive symptoms rather than a diagnosis of depression; problems with the operationalizations of BaCo and ExCo, and not being able to base the analyses on RCT data. Additional considerations concerning setting-related issues; the exclusion of a proxy-rated depressive symptoms measure, and the reasoning behind the different data-analytic approaches used can be found in the following sections.

7.3.1 Proxy Ratings in the Nursing Home Setting

Throughout the manuscript, particularities of the NH setting were important. With respect to limitations, these setting characteristics are once again important. Due to care staff workload, it was not possible to obtain care staff-rated ADL measurements or other care staff-rated measures. However, an immobility indicator could be obtained for all participants by research staff observations and performance-based BaCo measures could be obtained for ambulant residents (see Studies I and IV). For other measures, activity coordinators agreed to fill in for care staff and proxy-rated residents.

Moreover, due to the high staff turnover in German NHs (Neumann & Klewer, 2008), the high work load for NH staff, and an organizational change in NH 2 after baseline following a change in the Social Code (Section 87b(3) SGB XI from 01.01.2015), proxy ratings (social contact, activity participation, and cognitive impairment) were provided later than interview data and it was not always feasible to have the same staff member rate the same resident as on the prior occasion. Therefore, a rater-specific effect may have biased the ratings to some extent (method factor due to non-independent interchangeable raters; Eid et al., 2008; Koch et al., 2016). However, to maximize assessment reliability of proxy-rated data, previously evaluated items and scales were used (Köhler et al., 2007; Köhler et al., 2010; Lueken et al., 2006; Lueken et al., 2007; Marin et al., 1991) and questions on items were discussed with proxy raters before they filled out the questionnaires. The gain of using the measures was considered to outweigh their limitations given that observable data of ExCo-related activities are more objective and avoid a potential influence of depressive symptoms on self-ratings; given that proxies could provide information on residents who were unable (e.g., due to cognitive impairment) or unwilling to provide reliable information, and given that the measures had previously been evaluated regarding their psychometric quality for NH residents.

7.3.2 Depressive Symptoms Proxy Rating

The setting also made it difficult to obtain valid proxy ratings of depressive symptoms, which might have provided further insights into residents' mood. At least four established depressive symptoms proxy ratings may be used with old aged persons (i.e., the Hamilton Rating Scale for Depression, Hamilton, 1960; and the Montgomery-Åsberg Depression Rating Scale, Montgomery & Åsberg, 1979), some of which were developed for use with persons with dementia (i.e., the Cornell Scale for Depression in Dementia, Alexopoulos, Abrams, Young, & Shamoian, 1988; and the Dementia Mood Assessment Scale, Sunderland et al., 1988; for a review see Schneider, Weber, Maurer, & Frölich, 2002). All rely on participants' answers and interview behavior as well as on additional information, for example, concerning concentration, appetite, and sleep. The ratings should be done by clinicians or trained proxies who know residents very well. In the present studies, nursing staff who could have provided information were unavailable for the ratings. Activity-coordinating staff who also know residents very well acted as substitutes, assessing residents on the Montgomery-Åsberg Depression Rating Scale (MÅDRS, Montgomery & Åsberg, 1979). The MÅDRS was developed to be sensitive to change (Montgomery & Åsberg, 1979), has been validated in NH samples, including cognitively impaired residents (Leontjevas, Gerritsen, Vernooij-Dassen, Smalbrugge, & Koopmans, 2012), and has also been used as gold standard in validating a new depression scale in German NHs (Heidenblut & Zank, 2010).

Despite their efforts, activity-coordinating staff could not answer all MÅDRS items, with 99% missingness on *sleepiness* and 69% missingness on *loss of appetite* in NH 1, and 42% missingness on *suicidal thoughts* in NH 2 at pretest. Additionally, the MÅDRS was only utilized up to about half of the possible range (*Range* = 0–34) and correlated weakly and non-significantly with the GDS-12R ($r = .18$, $p > .05$), which raises questions about the MÅDRS's convergent validity. The high missingness and the systematic differences between the homes raised doubts about the validity of the established 10-item scale. Additionally, my decision to discard the MÅDRS from the analyses was substantiated by the limited range, low convergent validity with the GDS-12R, and suspicion that the problems arise from a lack of activity coordinators' knowledge on the relevant items.

7.3.3 Outcome Variable Distribution and Missing Values: Reasoning Behind the Different Data-Analytic Methods Used

The analytical approaches used in Studies I–IV vary considerably given the fact that all data were drawn from the same sample. Therefore, I would like to illustrate the reasoning behind the use of different approaches.

Whether deviations from the normal distribution or missing values are found problematic depends on the statistical procedures used, the expected effect sizes, and the missing data distribution, among others (see also Missing Data Handling in the Appendix). In the present dissertation, I tried to optimize the trade-off between adequately dealing with the outcome distribution and missing values. This is an issue because both factors guide the choice of the analysis technique which, in turn, affects sample size and thereby the power to detect a true effect.

Study I revealed some methodological issues that guided subsequent modeling choices. In this first study, a latent model was established that integrates categorical variables and extracts relationships between the latent, error-free BaCo, ExCo, and depressive symptoms variables. The method uses FIML in the estimation process so as to include residents despite missing values on some model-relevant variables. Using this technique, depressive symptoms were modeled on item level which circumvented modeling the skew scale distribution (see Chapters 2.5 and 3). However, the model was of critical complexity for the present data, as the simple structural model of interest required many measurement model parameters (i.e., 96/54 free parameters for the model with/out covariates). These had to be estimated from 196 observations that additionally showed a considerable amount of missing data (e.g., up to 53% for performance-based gait measures in Study I sample). The simulation study (robustness check in Study I) incorporated sample size and missing data patterns and showed that the estimated structural parameters were good with respect to their relative bias in the parameter and standard error estimations (all < 3%), and acceptable regarding their power (> .75 for the regression coefficients, .61 for the covariance). However, probing the measurement model parameters revealed the difficulties of the complex model in the present sample. Here, the loading and threshold estimates showed some bias (41% of measurement model parameters showed biases > 5%) with standard error estimates being more problematic (49% of measurement model parameters showed biases > 5%). The power concerning loadings and thresholds was, however, fine (all > .90) with the exception of two activity participation, two social contact, and the GDS_{13} threshold, which appeared to be close to zero (power of only .05). Considering these results and the intention to include further variable interactions in the model, I decided to simplify the measurement model for the following analyses. More precisely, I decided to use the depressive symptoms scale score; simplified versions of the proxy-rated single items (social contact), and an activity participation score.

Thus, the depressive symptoms outcome variable was considered as a scale to reduce model complexity starting from Study II. Available item scores were averaged if at least 25% of the scale items were answered. That is, the mean of the available items replaced the missing item values, which makes the scale calculation a simple form of ipsative mean imputation (Schafer & Graham, 2002). To counteract this method's hazards of basing the score on less item information, thereby decreasing reliability, the scale score was set as missing if more than three items were missing (Sutcliffe et al., 2000).

The distribution of these depressive symptoms scale scores at scale level, however, deviated from the normal distribution (see Distributional Assumptions of the Geriatric Depression Scale—Residential and Implications in the Appendix) as was expected from previous research (e.g., Diegelmann, Schilling, & Wahl, 2016; Schilling et al., 2016). Therefore, Studies II and III, which considered depressive symptoms as the outcome, employed GLMMs, which allow answering the research questions and accommodating the chosen gamma distribution for the depressive symptoms scale. However, GLMMs using SAS Proc Glimmix (SAS Institute Inc., 2011) cannot handle FIML and delete cases with missing data on model-relevant variables. That is, a resident could only be considered for data analysis if data on all model-relevant variables were provided one measurement occasion at a minimum. This also explains why the sample size in the longitudinal analyses (Studies II and III) was smaller than in the cross-sectional analysis in Study I. Residents with intermittent missingness or drop-in or drop-out status could be included on those occasions, at which they provided data on all model-relevant variables.

For the longitudinal analyses (Studies II and III), this information loss was acceptable as the number of available measurement occasions provided sufficient sample size (between $n = 104$ and $n = 163$ observations providing between 310 and 434 observations). For the cross-sectional Study IV, however, the sample size was smaller especially given that not all residents participated in the LS measurement ($n = 65$ participated in the Study IV sample).[13] Therefore, FIML estimations in MPlus were used again to maintain all available data points. Here, LS variables rather than depressive symptoms were the outcome measure and using the MLR estimator appeared as the best available choice to account for non-normality in the variables (Enders, 2001; MPlus does neither host a gamma distribution nor non-normally distributed independent variables).

7.4 Implications and Outlook

The studies presented showed the relevance of both BaCo and ExCo as major predictors of residents' depressive symptoms. They also underscored the overarching training effect of a BaCo-related PA promotion program and the impact of pretest variables on

[13] Residents without LS measurements were excluded from the analysis in this case.

the starting level of depressive symptoms development. Moreover, they showed the importance of examining ExCo-related activities differentially as well as the importance of considering activity enjoyability. Finally, they showed that depressive symptoms are associated with restricted LS. These insights may have practical value though they should be advanced to draw implications for future interventions counteracting depressive symptoms in the NH. Working from the present findings, three lines of future research appear to be particularly worthwhile: First, a more heterogeneous sample could be used to advance the knowledge on processes behind the presented findings. Second, future research may advance knowledge of moderating factors to further improve intervention designs. And third, the use of an improved version of the sensor-based LS tracking may advance knowledge of spatiotemporal, functional meanings of a certain LS area and how residents' whereabouts LS relate to their depressive symptoms.

First, future research is needed to advance the understanding of processes underlying the training effects (Studies II and III). Residents in the present NH sample developed homogeneously across the study time, as indicated by a lack of developmental variance (the random slope variance was close to zero in Study II and excluded altogether in Study III). Due to this homogeneous development, it was not reasonable to use latent change score models (convergence problems for change score models as well as for growth curve models with random slope variance and covariates). They would, however, be necessary in order to investigate training-related intra-individual change in one variable (e.g., BaCo) as a predictor of consequent intra-individual change in another variable (e.g., depressive symptoms). With respect to Study I results, it would appear particularly interesting to focus on the training-induced intra-individual change in perceived control and to investigate whether this change mediates between the training-induced BaCo change (Wingerath, 2016) and the expected intra-individual change in depressive symptoms (Meeks & Depp, 2003). This knowledge on processes underlying the training effects on depressive symptoms would offer a starting point for future intervention designs in order to boost their effects on depressive symptoms (e.g., increase perceived internal control to boost the intervention effect). The analyses could be done using latent change score models (Grimm, An, McArdle, Zonderman, & Resnick, 2012; McArdle, 2009; Steyer, 2005) given a larger and more heterogeneous sample than the present one.

Second, future research should further the knowledge of factors that moderate the training effect so as to consider these in improving the training design. Presented work showed that residents' contact with co-residents has an impact on their depressive symptoms (Studies I and III). The training effects on the frequency and enjoyability of these social relationships are, however, not currently known in the NH. Therefore, future research may build on the presented results and assess implementation versus non-implementation of meaningful co-resident contact in BaCo-related exercise RCTs in order to systematically investigate the contribution of meaningful co-resident contact to the training effect. Recognizing moderating factors may also help identify groups of residents who benefit most from an offered intervention or those features that boost the training gain.

Third, future research should use sensor-based LS measurements to focus in more detail on the role of social interactions in attenuating residents' depressive symptoms. Study III showed that enjoyable social interactions predict fewer depressive symptoms. The model of depressive symptoms in the NH, then, considers negative social interactions as a consequence of depressive symptoms (Lewinsohn et al., 1985; Meeks & Depp, 2003) which shows the crucial role of social contacts in the development, maintenance, and diminution of depressive symptoms. Furthermore, perceptions of social contacts are a crucial part of Muchow and Muchow's (1935) lived space or Lewin's (1936) psychological LS. These findings may expand the insights gained from focusing on the physical LS extension (Study IV) and advance the understanding of how depressed versus non-depressed residents differ in their social and environmental contexts across the day. To gain these insights, researchers may use a measurement burst design that allows tracking the change of residents' social and environmental context across the day at several time points (Calkins, 2001). Study IV further suggests a sensor-based method to track these social interactions. While it was not possible to measure all residents simultaneously, it might be so in the future. One could then easily identify places in which residents gather at certain times in the day and could then elaborate on the gathering groups (e.g., Who meets with whom? Did these residents meet before the training? Did they train in the same groups?). One could also attribute meaning-related characteristics of the meeting place to the gatherings (e.g., meeting to train in the training room during training time, meeting to chat in the lounge after supper), which would allow for characterizing the gatherings qualitatively (e.g., as organized or informal) and analyzing associations with depressive symptoms on a more precise time scale.

7.5 Conclusion

The present dissertation contributed to the important area of research on depressive symptoms in the NH in several ways. First, it added to a better understanding of the role of everyday activities in predicting residents' depressive symptoms. While previous research focused on BaCo *or* ExCo as predicting residents' depressive symptoms, the present study highlighted the importance of considering both (Study I).

Second, the present dissertation advanced the understanding of residents' depressive symptoms development and how a BaCo-related PA promotion program can alter this normative development. While previous exercise for depressive symptoms studies in the NH yielded inconsistent results, the present study used data from an intervention that was designed to overcome these shortcomings (e.g., by allowing residents to choose their training modality, by tailoring exercises according to residents' capabilities, by increasing the training intensity, and by training NH staff to sustainably implement the training). Applying GLMMs for gamma-distributed outcomes, which allows a direct test of the intervention effects, the present work showed that depressive symptoms of non-training residents increase across study time, while residents receiving training maintain their pretest depressive symptoms level. This significant post-intervention difference between the groups was maintained at follow-up (Study II). Furthermore, the present work addressed the role of different covariates (Study II) and of ExCo-related activities and their enjoyabilities (Study III), which supported the robustness of the intervention effects.

Third, the work also showed that different ExCo-related activities exhibit differential associations with residents' depressive symptoms. Whereas earlier research focused on the frequency of pleasant activities in predicting fewer depressive symptoms, the present work considered the frequency and enjoyability of an activity as separate predictors of residents' depressive symptoms and showed that activity enjoyability indeed adds important information to an understanding of the differential associations with depressive symptoms (Study III).

Fourth, the present research advanced the understanding of depressive symptoms in relation to residents' sensor-based LS. It introduced a sensor-based, in-home tracking system to measure residents' LS more objectively than had been previously done. The study described residents' LS and showed that cognitive, functional, and psychosocial factors influence residents' LS extension. Also, it showed that residents suffering from more depressive symptoms spent more time within their own room than residents suffering from fewer depressive symptoms (Study IV).

Considering this dissertation's findings, future research may design controlled BaCo-related intervention programs that implement enjoyable co-resident contact to test the potential of systematically changing residents' ExCo. The presented sensor-based LS measures are a very promising and sophisticated way of assessing change in social contact and LS, allowing innovative data-analytic procedures to link sensor-based ExCo performance with depressive symptoms in a very fine-tuned fashion.

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Tables

Figures

Abbreviations

ADL	activities of daily living
AES-D	Apathy Evaluation Scale
AIC	Akaike information criterion
ATC	Anatomical Therapeutic Chemical classification
BIC	Bayesian information criterion
BaCo	basic level of (everyday) competence
CFI	Comparative Fit Index
DSM	Diagnostic and Statistical Manual of Mental Disorders
DSS	Dementia Screening Scale
ExCo	expanded level of (everyday) competence
FES-I	Falls Efficacy Scale-International
FIML	full information maximum likelihood
GDS-15	15-item Geriatric Depression Scale
GDS-12R	12-item Geriatric Depression Scale–Residential
GLMM	generalized linear mixed model
IRT	Item Response Theory
LS	life-space
LTCMo	Long-Term Care in Motion
MÅDRS	Montgomery-Åsberg Depression Rating Scale
MAR	missing at random
MaxZ	maximal life-space zone a resident reached
MCAR	missing completely at random
MDD	major depressive disorder
MI	Bayesian multiple imputation

MinD	minor depressive disorder
ML	maximum likelihood
MLR	robust maximum likelihood
MMSE	Mini-Mental State Examination
MNAR	missing not at random
MSE	mean squared error
NH	nursing home
NHLSD	Nursing Home Life Space Diameter
PA	physical activity
PA-IG	group of residents who participated in the physical activity training
Nat-CG	group of residents who did not participate in the physical activity training, naturally occurring control group
PES	Pleasant Events Schedule
RCT	randomized controlled trial
RMSEA	root mean square error of approximation
RSSI	received signal strength indicator
SEM	structural equation modeling
SubD	subthreshold depression
t_0	baseline measurement (NH 2 only)
t_1	pre-intervention measurement
t_2	post-intervention measurement
t_3	follow-up measurement
TAFR	time away from the resident's room
TLI	Tucker–Lewis index
WIC	written informed consent
WLSMV	mean- and variance-adjusted robust weighted least squares estimation

Appendix

Further Data-Analytic Considerations

This appendix provides supplementary explanations of the GDS-12R's non-normal distribution and of missing data handling in general and in the presented studies. Furthermore, it displays additional tables describing the sample by NH site, death-related dropout, and measurement occasion.

Distributional Assumptions of the Geriatric Depression Scale—Residential and Implications

To better understand why it is crucial to investigate the variables', and especially the outcome's distribution, it is important to understand the statistics behind model parameter estimates. The frequentist approach to estimating model parameters is based on maximizing the likelihood of the data matrix (D) given the vector of assumed model parameters (θ). That is, the estimating algorithm aims at maximizing the probability $P(D \mid \theta)$ by estimating the model-defined population parameters (θ) that have the highest probability of reproducing the sample data (D). This can be achieved by minimizing the discrepancy between empirically-given model parameters (e.g., (co-)variances, means from D) and estimates of model-implied population parameters θ. The likelihood function is one tool to formalize and solve this optimization problem, that is, the discrepancy function:

$$P(D \mid \theta) = \mathcal{L} = \prod_{i=1}^{N} P(y_i, x_i \mid \theta) \qquad \text{(A1)}$$

where y_i refers to individual i's observed score on the outcome variable and x_i to i's observed values on the regressor variables. Please note that y_i and x_i may be matrices, rather than vectors, containing all model-relevant observed values for the individuals i in a sample so that they form the model-relevant data matrix D. According to equation A1, the likelihood is the product of each individual's likelihood value in a given sample of size N, given the parameter estimates θ. The sample likelihood $\mathcal{L}$, then, quantifies the discrepancy between the observed and the model-implied parameters and may therefore serve as a measure of relative model fit to the data (AIC and BIC are popular likelihood-based fit indices as well).

The optimized likelihood function can be characterized by the parameter estimates of a theoretical model that describes the given sample data adequately. Yet, the algorithms that maximize the likelihood function $\mathcal{L}$, (e.g., maximum likelihood [ML] estimations) require (1) observed data (D), (2) the specification of a theoretical model (θ), and (3) the specification of a *probability density function P* for the data. That is, all data points have to be drawn from an identical distribution[14] and the distribution of the error terms on y_i has to be specified as well[15]. Often, psychological research questions aim at quantifying these very parameters; therefore, it is important to describe one's data properly, to explicate the theoretical model, and also the distributional assumptions.

Commonly, outcome measures and their error terms are assumed to be normally distributed in the population. In Studies II and III, the outcome was the GDS-12R, which indicates the number of depressive symptoms during the last week. As depressive symptoms are likely to be highly right-skewed in old age samples (e.g., Diegelmann et al., 2016; Schilling et al., 2016) and as the outcome distribution is critical in regression analyses as explained above, the thesis's major outcome was investigated at each measurement occasion. Descriptive analyses revealed a high rate of zeros (25.4%, 22.5%, 23.9%, 25.6%, respectively) at each measurement occasion, which hints at considerable right-skewness and non-normality. To test for the normal distribution, SAS PROC UNIVARIATE (SAS Institute Inc., 2011) was used, which computes the Shapiro-Wilk statistic for sample sizes smaller than 2,000 (Royston, 1992). The statistic ranges from zero to one and depends on the sample size (as indicated by W_n). To additionally compare how well the normal distribution versus alternative distributions fit the data, I visualized the data and calculated squared difference Anderson-Darling statistics for the

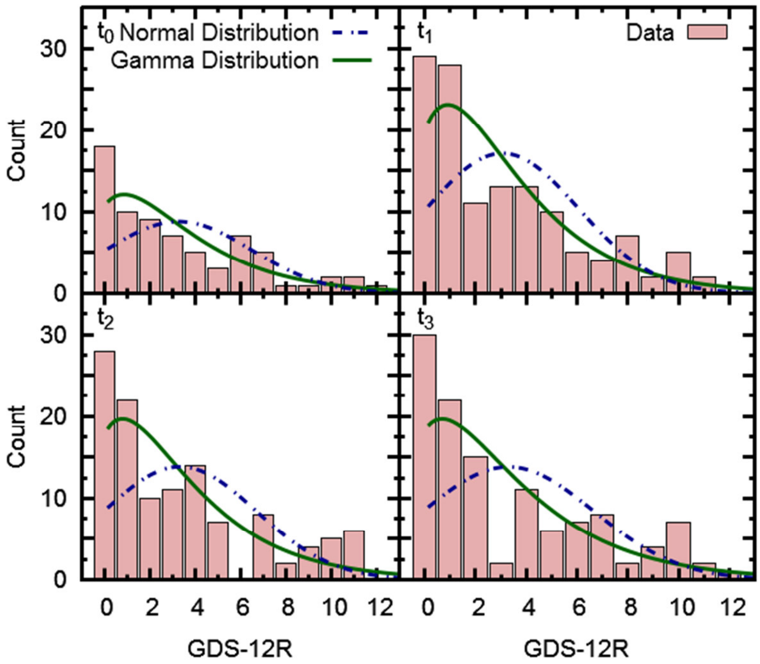
[14] Here, identical means that the random variables y_i and x_i have to be identically distributed across all individuals i. It does not preclude different distributions for y and x variables (e.g., y may be gamma-distributed and x may be normally distributed; if that is true for all individuals i, then x and y are drawn from an identical distribution).

[15] In common regression analyses, the random error terms ε_i of the regressand y_i are explicitly included in the regression model, while the regressor variables' error terms are not part of the regression model.

GDS-12R's distribution at every measurement occasion using SAS PROC UNIVARIATE (D'Agostino & Stephens, 1986; SAS Institute Inc., 2011). The alternative distributions tested were the beta, gamma, exponential (a special case of gamma), and lognormal distribution. These are continuous probability distributions, that is, functions that give the probability with which a random variable Y assumes a value of its range[16]. For example, they may give the probability that the number of depressive symptoms on the GDS-12R during the last week equals $h \in \{0, 1, \ldots, 12\}$.

The results of the distributional tests are displayed in Figure A1 and Table A1.

Figure A1 Distributions of the GDS-12R Across Measurement Occasions



[16] In mathematical terms, a random variable Y is the image that maps each possible outcome ($\omega \in \Omega$) on a value of the variable's range of possible outcomes Ω' ($Y: \Omega \rightarrow \Omega'$). For example, seven depressive symptoms ($\in \Omega$) are mapped to $y_i = 7$ ($\in \Omega'$). The distribution, then, is the function that gives the probability with which a random variable Y assumes a value (ω_i) of its range Ω'. For example, the gamma distribution gives the probability that the depressive symptoms variable assumes a given value (e.g., $\omega_i = 0$ with $\omega_i \in \Omega' = \{0, 1, \ldots, 12\}$).

Table A1 Distributions of the GDS–12R Across Measurement Occasions

Occasion	n	Skewness	Kurtosis	W_n	A^2 for the Normal Distribution	A^2 for the Gamma Distribution
Baseline	71	0.93	0.04	.88***	2.75**	1.63***
Pretest	129	0.95	-0.04	.87***	5.46**	2.84***
Posttest	117	0.95	-0.23	.85***	5.76**	2.68***
Follow-Up	117	0.86	-0.46	.86***	6.00**	3.47***

Notes. Significant Shapiro-Wilk test statistics W_n indicate substantial deviation of the data from the normal distribution; smaller values of the A^2 indicate better fit; $^{***}p < .001$, $^{**}p < .01$.

The normal distribution apparently did not describe the data well at any occasion as indicated by the unmodeled depressive symptoms counts especially in the case of few depressive symptoms in Figure A1 and the uniformly significant Shapiro-Wilk test statistics (rejecting the null-hypothesis of a univariate normally distributed variable; see Table A1). The non-normality appeared to be driven by the GDS-12R's right-skewness as all z values of skewness were above three, while the z values of kurtosis were all non-significant (not displayed). With respect to alternative distributions, the gamma distribution fit the data better than any other tested distribution at all measurement occasions (the smallest difference in the A^2 statistic was between the gamma and the beta distribution at baseline, -.09). For simplicity, only the fit statistics for normal and gamma distributions are displayed. The GDS-12R was thus modeled as a gamma-distributed variable whenever it was used as manifest outcome variable.

Now, what does this mean? The gamma distribution is characterized by two parameters, the shape k and the scale θ. While k determines the curve shape (e.g., bell, exponential), θ shrinks or stretches the curve. It models the expected value of depressive symptoms as measured by the GDS-12R as $E(\text{GDS-12R}_i + 1) = k\theta$ and its variance as $\text{Var}(\text{GDS-12R}_i + 1) = k\theta^2$. Notably, the gamma distribution is only defined for positive values, wherefore the outcome was rescaled (i.e., GDS-12R + 1). Given a gamma-distributed outcome, a linear regression, for example, would be modeled as

$$\ln(E(\text{GDS-12R}_i)) = \beta_0 + \beta_1 x_i + \varepsilon_i \qquad \text{(A2)}$$

Importantly, the error term ε_i is no longer assumed to be normally distributed—as in commonly used regression analyses—but as gamma-distributed:

$$e^{\varepsilon} \sim \Gamma(k, \theta) \qquad \text{(A3)}$$

Therefore, modeling depressive symptoms as gamma-distributed also changes the interpretation of the model parameters (see equation A2), and the assumed distributions of the error terms on the outcome (see equation A3). Given these modifications, valid likelihood-based parameter estimates can be derived from the present non-normal data.

Missing Data Handling

Statisticians distinguish different missing data mechanisms by categorizing them as missing completely at random (MCAR), missing at random (MAR), or missing not at random (MNAR). These differ in their assumptions regarding the relationship between the probability of missingness and the data. In short, the mechanisms can be formalized as

$$Y_{\text{complete}} = (Y_{\text{observed}}, Y_{\text{missing}}) \qquad \text{(A4)}$$

$$\text{MCAR:} \quad p(R \mid Y_{\text{complete}}) = p(R \mid \phi) \qquad \text{(A5)}$$

$$\text{MAR:} \quad p(R \mid Y_{\text{complete}}) = p(R \mid Y_{\text{observed}}, \phi) \qquad \text{(A6)}$$

$$\text{MNAR:} \quad p(R \mid Y_{\text{complete}}) = p(R \mid Y_{\text{observed}}, Y_{\text{missing}}, \phi) \qquad \text{(A7)}$$

with Y_{complete} notifying the hypothetical complete data, Y_{observed} notifying the observed data, and Y_{missing} notifying the missing data (Enders, 2010). R denotes a missing data indicator, and ϕ comprises parameters describing the relationship between R and the data (e.g., coefficients predicting the propensity for missing data). MCAR thus assumes that data on a variable Y are missing by chance and that missingness cannot be predicted by other variables in the model (equation A5). As data from a non-randomized natural lab approach were used, MAR appears to be more realistic in the present sample. It assumes that missingness is related to other model variables, but not to missing data itself (equation A6), and it ignores the process that caused the missingness while still allowing unbiased and efficient estimates given that the assumptions hold (Rubin, 1976). While MAR is also called *ignorable* missingness, MNAR is called *non-ignorable* or *informative* missingness. MNAR allows missing data to depend on the outcome variable itself, for example, on the unobserved outcome value (equation A7). Notably, MNAR can be turned into MAR by including variables into the model, which are capable of predicting missingness. However, so far it is neither possible to test the assumptions of MAR nor of MNAR. Recently, models to deal with MNAR have been implemented in standard software (e.g., Muthén, Asparouhov, Hunter, & Leuchter, 2011). However, they require relatively large samples for the models to converge and yield reliable estimates and were, thus, not attractive in the analyses of this dissertation.

Several methods allow for dealing with missing data. On the one hand, methods exclude observations with incomplete data, for example, listwise deletion. *Listwise deletion* requires that missing data are MCAR. When the missing data are not MCAR, listwise deletion results may be inconsistent—i.e., the estimate (e.g., a regression coefficient) does not converge in probability to the population value as the sample size tends to infinity. Because listwise deletion eliminates cases with incomplete data from the analyses, the resulting outcome distribution may be discrepant to the distribution in the population (see simulation in Schafer & Graham, 2002). Furthermore, the reduced complete-cases sample may be unrepresentative of the population (selectivity bias). When MCAR holds, listwise deletion results may still be inefficient as the estimates are based on a reduced sample, which may inflate standard error estimates and prevent the estimate's asymptotic mean squared error to reach the possible minimum as the sample size tends to infinity. However, some authors suggest that listwise deletion may be effective if missing data are prevalent in only a small and non-influential part of the sample (Schafer & Graham, 2002).

On the other hand, methods use all available data without deleting, replacing, or imputing data points, for example, *full information maximum likelihood* (FIML) techniques. FIML-based procedures estimate population values by maximizing the likelihood function, that is, the likelihood of the parameters given the available sample values. As in equation A8, the probability density function P has to be extended by the missing data indicators R_i and the parameter vector ϕ that describes the missing data propensity (see also equation A6):

$$P(D \mid \theta) = \mathcal{L} = \prod_{i=1}^{N} P(y_i, x_i, R_i \mid \theta, \phi) \quad \text{(A8)}$$

FIML estimations are based on maximizing the observed data's likelihood. That is, y_i and x_i are defined by their observed matrices together with the missing data indicators R_i and ϕ, which is unknown and ignored in the optimization process. Using Bayesian rather than frequentist notation, Rubin (1976) showed that $\mathcal{L}(\theta, \phi \mid y_i, x_i, R_i)$ is proportional to $\mathcal{L}(\theta, \mid y_i, x_i, R_i)$ if the missing data are MAR or MCAR. FIML thus assumes that missing data are MAR; that the model variables are multivariate normally distributed; and it requires relatively large samples. Given those prerequisites, FIML estimates are asymptotically unbiased, consistent, and efficient. Moreover, FIML techniques yielded relatively unbiased estimations across different MAR missing data rates, sample sizes, and degrees of non-normality in the manifest outcome variables of a structural equation measurement model (Enders, 2001). However, as the standard error estimates were negatively biased, Enders (2001) suggests using correction methods to prevent a bias in precision. Additionally, Enders (2001) and Enders and Bandalos (2001) showed in simulation studies that FIML estimations outperformed listwise deletion and two imputation techniques (mean imputation and similar response pattern imputation).

Other methods, then, impute missing data, for example, *Bayesian multiple imputation* (MI) techniques. In MI, each missing value is replaced by m ($m > 1$) simulated values, whereby m alternative versions of the complete data are generated. These data sets are then analyzed, and averaged overall estimates and standard errors are calculated. Because the data replacement is based on drawing parameters randomly from a Bayesian posterior distribution of the imputation parameters, MI yields slightly different data sets and analysis results every time it is used—even when used with the same observed data. Additionally, recent research showed that m should be larger than commonly assumed to maintain power in a given sample (Graham, Olchowski, & Gilreath, 2007) and therefore the technique is more time-consuming than FIML. Though simulation studies yield similar results comparing FIML and MI in dealing with MAR data (Newman, 2003; Olinsky, Chen, & Harlow, 2003), FIML rather than MI techniques were applied as they are easier to implement, easier to communicate, and yield identical results when run repeatedly on the same data set.

Concluding these considerations, FIML techniques were used to deal with missing data, where applicable. FIML yields asymptotically unbiased, consistent, and efficient estimates under MAR and allows for consideration of all available data points—without deleting or imputing missing data—, thus allows for maintaining the largest possible power given the present sample. Furthermore, robust estimators were used (e.g., MLR, mean- and variance-adjusted robust weighted least squares estimator [WLSMV]) to prevent precision bias (Enders, 2001), where applicable. For further reading on missing data, see, for example, Enders (2010), Graham (2009), or Schafer and Graham (2002).

Additional Tables and Figures

Table A2 Study Variables at Pretest by Site

	NH 1			NH 2				
Variable	*n*	*M**	(*SD*)	*n*	*M**	(*SD*)	Range	*p*
GDS-12R	53	2.6	(3.0)	76	3.4	(3.0)	0–11	.77
PA-IG	77	0.5		106	0.4		0–1	.53
Male	77	0.2		106	0.3		0–1	.99
Age (yr)	77	85.4	(8.4)	106	82.3	(10.4)	52.9–100.4	.38
Education (yr)	49	11.4	(3.7)	79	12.5	(3.7)	5–25	.76
Length-of-Stay (yr)	77	2.5	(2.4)	106	2.7	(1.9)	0.0–9.2	1
Died Within Study Period	77	0.2		106	0.1		0–1	1
Living on Dementia Care Unit	77	0.3		106	0.1		0–1	**<.01**
Mini-Mental State Examination	56	16.7	(8.1)	84	20.0	(7.8)	0–30	.26
Immobility	77	0.2		104	0.2		0–1	1
Speed (10m)	36	1.0	(0.4)	40	0.9	(0.4)	0.2–2.0	.96
Speed (4m)	37	0.8	(0.3)	41	0.8	(0.3)	0.2–1.8	.97
Self-Initiated Contact With Co-Residents	72	0.6		89	0.4		0–1	.19
Enjoys Talking With Co-Residents	54	0.4		76	0.4		0–1	.99
Self-Initiated Contact With Staff	70	0.7		90	0.5		0–1	.12
Enjoys Talking With Staff	50	0.6		75	0.6		0–1	1
Activity Participation	73	4.1	(2.4)	90	2.6	(2.0)	0–9	**<.001**
Enjoys Participating in Activities	50	0.6		76	0.4		0–1	.18
Internal Control	53	2.6	(1.0)	66	2.7	(0.9)	0–4	.99
External Control	48	1.8	(1.0)	65	1.8	(1.2)	0–4	1
Perceived Vision	54	2.4	(1.1)	85	2.5	(0.9)	0–4	1
Time-Away-From-Room (hr)	45	5.3	(2.0)	58	4.4	(2.6)	0.0–8.0	.66
Number of LS-Transits	45	6.6	(3.8)	58	6.3	(4.4)	0–17	1
LS-Score	45	1.7	(0.3)	58	1.7	(0.4)	1.0–3.1	.96
Maximal LS Zone a Resident Reached	45	2.8	(0.8)	58	2.8	(0.8)	1–4	1

Notes. *Fraction for dichotomous variables; *p* values from bootstrap step-down-corrected *t*-tests or Fisher's exact tests; significant *p* values in bold.

Table A3 Study Variables at Pretest by Death-Related Dropout

	Alive			Died Within Study Period				
Variable	*n*	*M**	(*SD*)	*n*	*M**	(*SD*)	Range	*p*
GDS-12R	110	3.1	(3.1)	19	2.7	(2.7)	0–11	1
PA-IG	156	0.5		27	0.3		0–1	.63
Male	156	0.3		27	0.4		0–1	.97
Age (yr)	156	83.1	(9.7)	27	86.9	(9.2)	52.9–100.4	.63
Education (yr)	111	12.4	(3.9)	17	10.1	(1.6)	5–25	.27
Length-of-Stay (yr)	156	2.5	(2.1)	27	3.1	(2.3)	0.0–9.2	.94
NH 2	156	0.6		27	0.6		0–1	1
Living on Dementia Care Unit	156	0.2		27	0.3		0–1	.98
Mini-Mental State Examination	122	19.2	(8.0)	18	15.3	(7.6)	0–30	.63
Immobility	155	0.2		26	0.4		0–1	.21
Speed (10m)	67	0.9	(0.4)	9	0.8	(0.3)	0.2–2.0	.97
Speed (4m)	69	0.8	(0.3)	9	0.7	(0.2)	0.2–1.8	.98
Self-Initiated Contact With Co-Residents	143	0.5		18	0.4		0–1	1
Enjoys Talking With Co-Residents	115	0.4		15	0.3		0–1	1
Self-Initiated Contact With Staff	141	0.6		19	.5		0–1	1
Enjoys Talking With Staff	111	0.5		14	0.7		0–1	.98
Activity Participation	145	3.3	(2.2)	18	2.9	(2.3)	0–9	1
Enjoys Participating in Activities	111	0.5		15	0.5		0–1	1
Internal Control	102	2.7	(1.0)	17	2.6	(1.0)	0–4	1
External Control	98	1.8	(1.1)	15	1.8	(1.2)	0–4	1
Perceived Vision	120	2.5	(1.0)	19	2.4	(1.1)	0–4	1
Time-Away-From-Room (hr)	92	4.7	(2.4)	11	5.2	(2.6)	0.0–8.0	1
Number of LS-Transits	92	6.5	(4.3)	11	6.1	(2.9)	0–17	1
LS-Score	92	1.7	(0.4)	11	1.7	(0.3)	1.0–3.1	1
Maximal LS Zone a Resident Reached	92	2.8	(0.8)	11	2.5	(0.5)	1–4	.91

Notes. *Fraction for dichotomous variables; *p* values from bootstrap step-down-corrected *t*-tests or Fisher's exact tests; significant *p* values in bold.

Table A4 Study Variables by Measurement Occasion

	Baseline			Pretest			Posttest			Follow-Up				
Variable	*n*	*M**	(*SD*)	*n*	*M**	(*SD*)	*n*	*M**	(*SD*)	*n*	*M**	(*SD*)	Range	*p***
GDS-12R	71	3.3	(3.2)	129	3.1	(3.0)	117	3.3	(3.3)	117	3.3	(3.4)	0–12	1
PA-IG	104	0.4		183	0.4		180	0.4		178	0.4		0–1	1
Male	104	0.3		183	0.3		180	0.3		178	0.3		0–1	1
Age (yr)	104	82.5	(10.1)	183	83.6	(9.7)	180	83.2	(9.9)	178	83.3	(9.4)	52.5–100.7	1
Education (yr)	77	12.6	(3.9)	128	12.1	(3.8)	112	12.2	(3.8)	111	12.5	(4.1)	5–28	1
Length-of-Stay (yr)	104	2.5	(1.9)	183	2.6	(2.1)	180	2.7	(2.1)	178	2.7	(2.1)	0.0–9.8	1
NH 2	104	1.0		183	0.6		180	0.6		178	0.6		0–1	**<.001**
Died Within Study Period	104	0.2		183	0.1		180	0.1		178	0.0		0–1	**<.001**
Living on Dementia Care Unit	104	0.1		183	0.2		180	0.2		178	0.2		0–1	.94
Mini-Mental State Examination	73	21.2	(7.0)	140	18.7	(8.0)	118	19.4	(8.1)	119	19.8	(8.1)	0–30	.81
Immobility	102	0.2		181	0.2		180	0.2		178	0.2		0–1	1
Speed (10m)	50	0.8	(0.3)	76	0.9	(0.4)	78	1.0	(0.4)	79	0.9	(0.4)	0.1–2.3	1
Speed (4m)	51	0.8	(0.4)	78	0.8	(0.3)	79	0.9	(0.4)	80	0.8	(0.3)	.1–2.0	1

(continued on next page)

Table A4 *(continued)*

	Baseline			Pretest			Posttest			Follow-Up				
Variable	*n*	*M**	(*SD*)	*n*	*M**	(*SD*)	*n*	*M**	(*SD*)	*n*	*M**	(*SD*)	Range	*p*
Self-Initiated Contact With Co-Residents	98	0.4		161	0.5		169	0.5		157	0.6		0–1	.99
Enjoys Talking With Co-Residents	69	0.4		130	0.4		117	0.4		116	0.4		0–1	1
Self-Initiated Contact With Staff	96	0.6		160	0.6		169	0.6		161	0.7		0–1	.99
Enjoys Talking With Staff	70	0.6		125	0.6		115	0.6		113	0.6		0–1	1
In-home Activity Participation	97	2.9	(2.3)	163	3.3	(2.3)	173	3.0	(2.2)	160	3.0	(2.2)	0–9	1
Enjoys Participating	72	0.4		126	0.5		117	0.5		106	0.6		0–1	1
Internal Control	60	2.6	(1.0)	119	2.7	(1.0)	107	2.7	(1.0)	110	2.7	(1.0)	0–4	1
External Control	61	1.9	(1.2)	113	1.8	(1.1)	102	1.9	(1.2)	107	1.9	(1.1)	0–4	1
Perceived Vision	77	2.5	(0.9)	139	2.4	(1.0)	124	2.4	(1.0)	125	2.5	(1.0)	0–4	1
Time-Away-From-Room (hr)	66	4.7	(2.4)	103	4.8	(2.4)	101	5.3	(2.4)	98	4.7	(2.5)	0–8	1
Number of LS-Transits	66	7.9	(5.5)	103	6.4	(4.1)	101	6.4	(4.4)	98	6.9	(4.7)	0–17	.89
LS-Score	66	1.8	(0.4)	103	1.7	(0.4)	101	1.8	(0.3)	98	1.7	(0.4)	1–3	1
Maximal LS Zone a Resident Reached	66	2.9	(0.6)	103	2.8	(0.8)	101	2.9	(0.7)	98	2.8	(0.7)	1–4	1

Notes. Baseline measurements for NH 2 only; *fraction for dichotomous variables; **smallest *p* values from contrasts to pretest; *p values* from Bonferroni step-down-corrected *t*-tests or Fisher's exact tests; significant *p* values in bold.

Personal Contributions to Studies I–IV

Data Generation

Hans-Werner Wahl and Klaus Hauer designed and headed LTCMo; Carl-Philipp Jansen, Katrin Claßen, and Eva-Luisa Schnabel were project managing research staff in LTCMo. I helped them in all phases of data gathering, for example, in choosing the depressive symptoms scales, recruiting residents and gathering WICs, training and supervising research assistants, gathering the data (prepare proxy ratings, draw data from the homes' care documentations, conduct interviews, conduct performance-based tests, help record LS and accelerometry), supervising data entering, screening and managing data from interviews, proxy ratings, and care documentation.

Studies I–III

Together with Hans-Werner Wahl and Oliver K. Schilling I developed the ideas. I conducted the statistical analyses, which were supervised by Oliver K. Schilling. Together with Hans-Werner Wahl and Oliver K. Schilling I interpreted the data and drafted the paper.

Study IV

I commented on the theoretical background of the paper as well as on LS data preparation. I conducted the descriptive analyses for Figure 6.2, produced this figure, and conducted the regression analyses according to Carl-Philipp Jansen's ambitions. I—as all coauthors—revised and approved the draft.

Erklärung gemäß § 8 Abs. (1) c) und d) der Promotionsordnung der Fakultät für Verhaltens- und Empirische Kulturwissenschaften

Promotionsausschuss der Fakultät für Verhaltens- und Empirische Kulturwissenschaften der Ruprecht-Karls-Universität Heidelberg

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Ich erkläre, dass ich die vorgelegte Dissertation selbstständig angefertigt, nur die angegebenen Hilfsmittel benutzt und die Zitate gekennzeichnet habe.

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Ich erkläre, dass ich die vorgelegte Dissertation in dieser oder einer anderen Form nicht anderweitig als Prüfungsarbeit verwendet oder einer anderen Fakultät als Dissertation vorgelegt habe.

Vorname Nachname Mona Diegelmann

Datum, Unterschrift 27.02.2017 ______________________________