

# Relationships Between Housing and Healthy Aging in Very Old Age

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**Purpose:** The aim of this work is to examine the relationship between aspects of objective and perceived housing and aspects of healthy aging, defined as independence in daily activities and subjective well-being. Furthermore, this research examined the comparability of relationships between housing and healthy aging in the five European countries. **Design and Methods:** Data were drawn from the ENABLE-AGE Project, from home interviews with a sample of 1,918 very old people aged 75 to 89 years living alone in their own homes in Swedish, German, British, Hungarian and Latvian urban areas. **Results:** Participants living in better accessible homes, who perceive their home as meaningful and useful, and who think that external influences are not responsible for their housing situation are more independent in daily activities and have a better sense of well-being. Moreover, these results apply to all five national samples. **Implications:** The findings can widen the perspective when striving for barrier-free building standards, to encompass a holistic approach that

takes both objective and perceived aspects of housing into account. Home modification and relocation should not be prescribed, but need to be negotiated with older adults to take into account their personal preferences.

*Key Words:* Environmental gerontology, Person-environment fit, Accessibility, Home, Well-being

As people age, housing modifications become important to compensate for and assist in their adaptation to declining functional capacity in order to maintain a sense of well-being and independence in daily life (AARP, 2005; Baltes, Maas, Wilms, Borchelt, & Little, 1999; Gitlin, 1998; Wahl, 2001). In very old age in particular, the relationship between housing and health is significant, because older adults have an increased vulnerability to environmental challenges (Iwarsson, 2005). Previous studies have focused on the impact of home hazards on negative health events particularly, such as falls (Gitlin, 2003; Oswald & Wahl, 2004), but generally the evidence about a link between housing and health is limited (Ferrucci et al., 2004; Gitlin et al., 2006; Oswald & Wahl; Spillman, 2004). This study was based on the ENABLE-AGE Project, which is a cross-national, interdisciplinary European project that aims to increase knowledge about such relationships (see also Iwarsson et al., this issue).

Furthermore, housing is linked to the existing sociocultural background of a person (e.g., Rubinstein & De Medeiros, 2004). Cultural differences in this regard are often addressed in terms of developmental contexts in early life (Chawla, 1992), various migration patterns after retirement (e.g., Serow, Friedrich, & Haas, 1996), or as differences that are due to climate, religious background, and economics (e.g., Hay, 1998). Beyond such contrasts, cross-national housing-related research with older adults has remained quite rare (Iwarsson, Wahl, & Nygren,

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2004), yet it is important for shedding light on cross-national similarities and differences of relationships between housing and health.

Our understanding of health is based on the definition by the World Health Organization (WHO) of health as “a state of complete physical, mental and social well-being, and not merely the absence of disease or handicap” (WHO, 1948). Against this background, the WHO’s International Classification of Functioning and Disability (ICF; WHO, 2001) has often been used in rehabilitation practice and research (Dahl, 2002; Haigh et al., 2001). Within this scheme, the components of body functions and structure, as well as activity and participation, are interrelated and the environmental and personal factors have an interfacing role in these dynamics (WHO, 2001). On the basis of the ICF classification, in the ENABLE-AGE Project we used the term *healthy aging* to address selected aspects of physical, mental, and social health that we assume to be particularly relevant to housing. Among these concepts are independence in daily activities and subjective well-being (Iwarsson et al., 2004). Accordingly, well-established definitions of healthy aging emphasize aspects of physical, social, and emotional health (Vaillant, 2002), or the maintenance of optimal physical, mental, and social well-being and function in older adults, which are most likely to be achieved when environmental conditions are adequate (Healthy Aging Research Network, 2005).

Independence covers daily activities at home to execute a task or action by an individual (WHO, 2001). The relevance of daily activities for aging has been shown in prior research, in which older people performed the major part of their activities at home (Baltes et al., 1999). Beside daily routines, particularly meaningful activities can contribute to independence and health in later life (Clark et al., 1997). Thus, we assume that housing-related behavior is linked to healthy aging in terms of independence in daily activities.

Subjective well-being addresses how good an individual feels about his or her life at a given time, and this construct includes cognitive and affective components (Diener, Suh, Lucas, & Smith, 1999). Concerning cognitive aspects of well-being, the global judgment of life satisfaction (e.g., Diener et al., 1999; Veenhoven, 1996) and also the differentiated assessment of specific psychological domains, such as the sense of mastery and competence in managing the environment, have been found to be associated with health in later life (Ryff, 1989; Ryff, Singer, & Love, 2004). As far as affective aspects of well-being are concerned, the presence of positive affect and the absence of negative affect (Mroczek & Kolarz, 1998; Watson, Clark, & Tellegen, 1988) as well as low levels of depression (e.g., Sheik & Yeavage, 1986) are considered to indicate healthy aging in very old age (Diener et al., 1999). Although some studies have revealed empirical relationships

between housing amenities and evaluations of well-being in later life (Iwarsson & Isacsson, 1997; Oswald, Wahl, Mollenkopf, & Schilling, 2003), specific aspects of objective and perceived housing and their relationship to various aspects of subjective well-being require empirical investigation.

### *Perspectives on Housing and Healthy Aging from Environmental Gerontology*

From an environmental gerontology perspective, the relation of housing and health is closely linked to the ecological theory of aging (Lawton, 1982, 1987; Lawton & Nahemow, 1973; Scheidt & Norris-Baker, 2004) as well as models of person-environment (P-E) fit as suggested by Kahana (1982) and Carp (1987). One of the main assumptions of these models is that outcomes of P-E interaction are not exclusively predicted by either personal competences or environmental conditions, but by the individual level of P-E fit. Both theories argue that the equilibrium between individual competence and environmental press is especially unstable in very old age, as adaptive capacities decrease with aging. So far, research has shown that barriers in the physical environment cause problems as a result of the older person’s functional capacity (Fänge & Iwarsson, 2003; Iwarsson, 2005; Stark, 2004; Wahl, Oswald, & Zimprich, 1999; Wahl, Schilling, Oswald, & Heyl, 1999). This underpins the need for researchers to address P-E fit rather than personal and environmental aspects separately when they are investigating health in old age (Iwarsson, 2004, 2005). In the ENABLE-AGE Project, we saw objective aspects of housing as a facet of P-E fit, referred to as accessibility (Iwarsson, 2005) or the relationship between a person’s functional limitations and the prevalence of physical environmental barriers at home (Iwarsson & Ståhl, 2003). In the remainder of this article, we use the term *accessibility* to refer to this.

Although important, targeting only objective aspects of housing would neglect the experiential dimension of aging in place (Altman & Low, 1992; Oswald & Wahl, 2005; Rowles & Chaudhury, 2005). Housing in later life acquires new meanings for elderly individuals as a result of the long duration of living in the same home, familiarity, and processes of attachment (Evans, Kantrowitz & Eshelman, 2002; Rowles, Oswald, & Hunter, 2004; Rubinstein & De Medeiros, 2004; Sixsmith & Sixsmith, 1991). Here we use the term *perceived housing* to address a scope of subjective phenomena of experiences related to housing. In particular, the ENABLE-AGE Project addresses housing satisfaction, usability, meaning of home, and housing-related control beliefs (see also Nygren et al., this issue).

Housing satisfaction reflects the perceived quality of the home in terms of a broad attitudinal evaluation (Aragonés, Francescano, & Gärling, 2002;

Weideman & Anderson, 1985). Older people seem to be particularly adept at adapting to different objective living conditions and sustaining high levels of housing satisfaction (Rowles et al., 2004). Thus, to analyze the relationship between perceived housing and healthy aging, researchers must move beyond the idea of housing satisfaction.

The construct of usability has been developed within occupational therapy to address perceived possibilities for activities at home (Fänge & Iwarsson, 2003). Empirical studies have emphasized the relationship between housing accessibility and usability (Fänge & Iwarsson, 2003), as well as changes involving home modification (Fänge & Iwarsson, 2005).

Based on theories of place identity (e.g., Proshansky, Fabian, & Kaminoff, 1983; Stedman, 2002), the meaning of home is a concept used to cover subjective evaluations, goals, values, cognitions, and emotions of a person in relation to her or his home (Marcus, 1995; Moore, 2000; Oswald & Wahl, 2005; Sixsmith & Sixsmith, 1991). In contrast to satisfaction and usability, meaning covers affective, cognitive, behavioral, and social bonds to the home (Rowles & Watkins, 2003), manifest through processes of symbolic representation, familiarity, and routines. To date, studies show that different meaning patterns among older people with severe visual compared with mobility impairments can serve as a resource to cope with dependence in daily activities (Oswald & Wahl, 2005).

Another strand of research derives from psychological theories on perceived control (Lachman, 1986; Levenson, 1981). Control beliefs have been found to reflect a driving force in explaining the course and outcome of aging (Heckhausen & Schulz, 1995; Smith, Marsiske, & Maier, 1996). Housing-related control beliefs (Oswald, Wahl, Martin, & Mollenkopf, 2003) explain events at home either as contingent upon one's own behavior or upon external influences. Longitudinal studies show that external control beliefs are especially sensitive to age differences and changes, and thus are particularly crucial in relation to independence in daily activities and well-being (e.g., Baltes, Freund, & Horgas, 1999).

In sum, although prior studies have investigated links between healthy aging and housing, the need remains for a comprehensive study of "the interrelationships between the home environment, psychological well-being, and daily functioning throughout the aging process" (Gitlin, 2003, p. 631f). This is particularly important in very old age, because it is not known how aspects of objective and perceived housing and healthy aging are intertwined, which is the focus of this investigation.

Taking all together, a scattered picture remains when the relation between housing and healthy aging is the target of an empirical analysis. On the one hand, conceptually driven reasons for assuming substantial relationships between objective and perceived housing variables and indicators of behavioral

independence and well-being are available. On the other hand, empirical evidence on these relationships is still surprisingly scarce, particularly for the array of variables on perceived housing. Recent results from the ENABLE-AGE Project shed some light on these issues (see Nygren et al., this issue). Going further, there is practically no empirical research addressing objective and perceived aspects of housing in a simultaneous manner with respect to a range of healthy aging outcomes. Thus, our aim with this contribution is to explore patterns of relationships between aspects of objective and perceived housing and healthy aging in very old age, based on data from the ENABLE-AGE Project. Moreover, we want to explore whether comparable relationships do exist in the five national samples, which are Sweden, Germany, the United Kingdom (UK), Hungary, and Latvia.

## Methods

### *Participants*

This study is based on data collected for the first wave of the ENABLE-AGE Survey Study (see Iwarsson et al., this issue). We gathered data in urban regions in five European countries representing economically well-developed "old" European Union member states (Germany, the UK, and Sweden) as well as "new" member states that joined the European Union only in 2005 and still are in a period of major social and political transformation (Hungary and Latvia; see Széman & Harsanyi, 2000). The target sample in each country was very old individuals living in single-person households in geographically defined urban areas. Because people in Sweden, Germany, and the UK have a longer life expectancy than do people in Latvia and Hungary, the participants in Sweden, Germany, and the UK consisted of adults aged 80–89 years, whereas those in Latvia and Hungary consisted of adults aged 75–84 years. In total, the sample included 1,918 participants (78% women, 22% men). As far as the sociodemographic variables are concerned, differences in finances reflect lower income in the Eastern compared with the Western national samples, whereas differences in education were minor. Basic health indicators also varied among the national samples, with slightly better health in the Western compared with the Eastern samples (for details, see Table 1; see also Iwarsson et al. and Nygren et al., this issue).

### *Procedures and Sample Recruitment*

After project-specific training and completion of an interrater reliability study (Iwarsson, Nygren, & Slaug, 2005), interviewers collected data at home visits. In Sweden, Germany, and Latvia, the interviewer teams consisted of occupational therapists,

Table 1. Sample Description

Variable	Sweden	Germany	UK	Hungary	Latvia
Year of birth	1912–22	1912–22	1912–22	1917–27	1917–27
Age range (years)	80–89	80–89	80–89	75–84	75–84
Age ( <i>M</i> , <i>SD</i> )	84.6 (3.1)	85.1 (3.2)	84.8 (2.7)	80.7 (2.9)	79.4 (2.6)
Gender (% women)	74.6	78.4	70.0	80.6	88.5
Education: years of schooling ( <i>M</i> , <i>SD</i> )	8.8 (2.2)	11.6 (2.6)	9.9 (1.9)	9.7 (3.0)	11.3 (3.4)
Income/month in € ( <i>M</i> , <i>SD</i> ) <sup>a</sup>	1,015 (410)	1,569 (799)	1,044 (527)	216 (99)	100 (37)
Evaluation of financial resources (% , <i>n</i> ):					
Low	34.4 (130)	17.4 (76)	23.4 (86)	56.5 (218)	87.9 (262)
Average	54.5 (206)	73.3 (321)	65.5 (241)	39.9 (154)	12.1 (36)
High	11.1 (42)	9.4 (41)	11.1 (41)	3.6 (14)	0.0 (0)
General perceived health (1–5) <sup>b</sup>	2.8 (1.1)	3.6 (0.8)	3.0 (1.0)	3.5 (1.0)	4.2 (0.7)
Number of diseases (0–44) <sup>c</sup>	4.9 (2.9)	5.3 (3.0)	4.2 (2.7)	6.1 (3.9)	7.9 (3.4)
Number of symptoms (0–30) <sup>c</sup>	7.3 (4.3)	8.0 (4.5)	8.1 (4.9)	10.7 (6.6)	13.8 (5.3)
Duration of living in same apartment or house: years ( <i>M</i> , <i>SD</i> )	21.8 (17.4)	33.5 (19.4)	25.0 (18.3)	33.9 (19.2)	24.7 (16.6)

Notes: For the total number of participants,  $N = 1,918$ ; for Sweden, Germany, the UK, Hungary, and Latvia,  $n = 397, 450, 376, 392,$  and  $303,$  respectively. *SD* = standard deviation.

<sup>a</sup>In total, 269 participants (14%) refused to give information on income per month.

<sup>b</sup>Subjective evaluation; higher scores indicate lower subjective health (according to the Short Form-36).

<sup>c</sup>Higher scores indicate more reported diseases or symptoms.

whereas the UK and Hungarian interviewer teams were multidisciplinary (Iwarsson et al., 2004). In Sweden, Germany, and Hungary, participants were drawn at random from official national registers. In the UK, the sampling strategy relied on the use of general practitioners' lists, whereas in Latvia participants were recruited at social day care centers and through older people's voluntary organizations. All participants were enrolled after informed consent, following the ethical guidelines and procedures for formal ethical consent of each country (see Iwarsson et al., this issue).

### Instruments

**Objective Aspects of Housing.**—We operationalized objective housing as the number of environmental barriers in the home and the magnitude of accessibility problems, which we assessed by using the Housing Enabler instrument (Iwarsson & Slaug, 2001). For this study, we developed and tested a cross-national research version that showed sufficient reliability (Iwarsson, Nygren, et al., 2005). The instrument is administered in three steps, the first of which is the dichotomous assessment of the personal component of accessibility, measured through interview and observation and covering both functional limitations (13 items) and dependence on mobility devices (2 items). The second step is the assessment of the environmental component of accessibility that includes physical environmental barriers. This is a detailed observation assessing the presence or absence of environmental barriers in the home and the immediate outdoor environment (188 items). The third step is the calculation of the accessibility score. For each environmental barrier

item, the instrument includes predefined severity ratings (Steinfeld et al., 1979), operationalized as points (1–4) quantifying the severity of the accessibility problems predicted to arise in each case. The severity scale is scored 1 to 4, where 1 represents a potential accessibility problem and 4 represents a very severe accessibility problem. On the basis of the assessments in Steps 1 and 2, with use of a complex matrix including the predefined severity ratings from 1 to 4, the profile of functional limitations identified for each person is juxtaposed with the environmental barriers present in the home environment. The sum of all the predefined points is used to calculate a score that indicates the magnitude of accessibility problems caused by a particular combination of functional limitations and environmental barriers (i.e., the magnitude of accessibility problems). In cases in which no functional limitations or dependence on mobility devices are present, the score is always zero; higher scores mean more accessibility problems (for more details, see Iwarsson, 2005; Nygren et al., this issue).

**Perceived Aspects of Housing.**—We assessed housing satisfaction with a single-item evaluation (“Are you happy with the condition of your home?”), scored 1–5, which we adapted from the Housing Options for Older People questionnaire (Heywood, Oldman, & Means, 2002; Sixsmith & Sixsmith, 2002).

In order to capture usability, we applied the 16-item Usability in My Home questionnaire (Fänge & Iwarsson, 1999, 2005), addressing the degree to which the physical housing environment supports the performance of activities at home (scored 1–5). The items of the instrument address “activity aspects,”

“personal and social aspects,” and “physical environmental aspects” of usability (Fänge & Iwarsson, 2003). As a result of the low internal consistency in this study, we excluded the Personal and Social Aspects subscale. We retained the Physical Environmental Aspects (6 items;  $\alpha = 0.84$ ) and Activity Aspects (4 items;  $\alpha = 0.84$ ) subscales (for details, see Nygren et al., this issue).

To measure meaning, we used the 28-item self-evaluation Meaning of Home questionnaire, assessing the physical, behavioral, cognitive-emotional, and social meaning of home (scored 0–10; see Oswald, Mollenkopf, & Wahl, 1999). The items in each area were purposefully selected to represent a wide range of topics; thus, internal consistency was expected to be rather low (Kline, 1993). Examples of items and internal consistency scores for each of the four aspects are as follows: physical aspects included 7 items, sum-score  $\alpha = 0.69$ ; behavioral aspects included 6 items, sum-score  $\alpha = 0.67$ ; cognitive-emotional aspects included 10 items, sum-score  $\alpha = 0.66$ ; and social aspects included 5 items, sum-score  $\alpha = 0.55$  (for details, see Nygren et al., this issue).

We assessed housing-related control beliefs with the Housing-Related Control Beliefs Questionnaire, which is based on the dimensions of internal control (8 items), external control: powerful others (8 items), and external control: chance (8 items; scored 1–5; see Oswald, Wahl, Martin, et al., 2003). Internal control means that housing-related events are highly contingent upon a person’s own behavior, whereas personal responsibility implies that one is responsible for what happens. External control means either some other person is responsible or things happen by luck, chance, or fate. Because there was low internal consistency in the present data set, we did not use the Internal Control subscale. Further, we combined the two External Control subscales, resulting in sufficient reliability for the 16 items included (sum-score  $\alpha = 0.72$ ; for details, see Nygren et al., this issue).

### *Indicators of Healthy Aging*

We assessed objective (i.e., based on professional judgment) independence in activities of daily living (ADLs) by using the ADL Staircase (Sonn & Hulter-Asberg, 1991). This instrument is an extension of Katz’s ADL Index (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963), comprising five personal ADL (PADL) items (i.e., feeding, transferring, going to the toilet, dressing, and bathing) and four instrumental ADL (IADL) items (i.e., cooking, shopping, cleaning, and using transportation). One administers the ADL Staircase by using a combination of interview items and observation, and the assessment level is a person’s dependence on assistance from another person when performing an activity. The assessment is recorded on a three-graded scale: independent, partly dependent, and dependent. The validity and reliability of the instru-

ment have been demonstrated in several studies on community-living older people (Iwarsson, 2005; Iwarsson & Isacsson, 1997; Sonn & Hulter-Asberg, 1991). In the ENABLE-AGE Project, we applied a rank-based data-treatment approach, in which the assignment of ranks is based on an itemwise comparison of response patterns in the sample (Iwarsson, Isacsson, & Lanke, 1998, Iwarsson & Lanke, 2004). Moreover, we assessed perceived independence in ADLs by using a single-item self-evaluation measure from the Neuropsychological Aging Inventory (scored 0–10; see Oswald, 2005).

Subjective well-being included cognitive aspects (life satisfaction and environmental mastery), and emotional aspects (affect and depression). We assessed life satisfaction by using a single-item self-evaluation measure (scored 0–10), and we assessed environmental mastery by using one subscale of the Psychological Well-Being Questionnaire (Ryff, 1989). This instrument originally included nine subscales; we selected the Environmental Mastery subscale (9 items) for this research. This subscale addresses sense of mastery and competence in managing the environment (scored 1–5), including statements such as “In general, I feel I am in charge of the situation in which I live” (internal consistency,  $\alpha = 0.80$ ).

We assessed affect by using the Positive and Negative Affect Schedule (Watson et al., 1988), yielding a score based on 10 items for both negative and positive affect that have consistently shown to be independent from each other (Staudinger, Freund, Linden, & Maas, 1999; Watson & Clark, 1997). Interviewers instructed participants to judge how frequently they experienced 20 emotions during the past year (scored 1–5). Examples of positive affect items are interested, excited, strong, active, inspired (internal consistency,  $\alpha = 0.76$ ); examples of negative affect are distressed, guilty, nervous, afraid, and ashamed (internal consistency,  $\alpha = 0.78$ ).

We assessed depression and depressive symptoms with the 15-item version of the Geriatric Depression Scale (Yesavage et al., 1983). Interviewers instructed participants to judge (yes–no) how they felt over the past week on questions such as “Do you feel that your situation is hopeless?” or “Are you in good spirits most of the time?” (internal consistency,  $\alpha = 0.82$ ).

### *Data Analysis and Statistical Methods*

We tested the mean differences between national samples in basic variables of healthy aging by means of *F* tests. Because the sample size was large, we set the statistical significance level at  $p < .001$ . Given the goal of obtaining relationships between various housing and healthy aging measures, the statistical exploration of relationships called for the use of multivariate analysis techniques.

We used the technique of canonical correlations, which, according to Stevens (1996), is the most appropriate technique for exploring relationships

Table 2. Basic Description of Healthy Aging Aspects in the Five National Samples

Variable ( <i>M, SD</i> )	Sweden	Germany	UK	Hungary	Latvia	Diff.
Age (years)	80–89	80–89	80–89	75–84	75–84	
ADL independence (0–9) <sup>a</sup>	7.6 (1.6)	7.8 (1.4)	8.0 (1.5)	7.9 (1.5)	8.2 (1.5)	***
Perceived functional independence (0–10) <sup>a</sup>	8.5 (1.9)	8.1 (2.1)	8.0 (1.5)	8.0 (2.5)	7.3 (2.2)	***
Life satisfaction (0–10) <sup>b</sup>	8.5 (1.7)	8.5 (1.8)	8.2 (1.8)	6.6 (2.4)	5.5 (2.0)	***
Environmental mastery (1–5) <sup>c</sup>	4.0 (0.5)	4.4 (0.6)	3.9 (0.5)	4.0 (0.7)	3.2 (0.5)	***
Positive affect (1–5) <sup>d</sup>	3.2 (0.6)	3.4 (0.7)	3.4 (0.6)	3.4 (0.6)	3.1 (0.5)	***
Negative affect (1–5) <sup>d</sup>	2.1 (0.5)	2.0 (0.6)	2.0 (0.6)	2.1 (0.6)	2.5 (0.5)	***
Depression (0–15) <sup>e</sup>	3.0 (2.3)	3.2 (2.9)	3.0 (2.6)	5.5 (3.6)	6.4 (4.0)	***

Notes: For the total number of participants,  $N = 1,918$ ; for Sweden, Germany, the UK, Hungary, and Latvia,  $n = 397, 450, 376, 392,$  and  $303,$  respectively. ADL = activity of daily Living;  $SD$  = standard deviation. Statistical test for differences:  $F$  test,  $p < .001$ . All standard deviation differences  $>0.05$  (ADL independence),  $>0.72$  (perceived functional independence),  $>1.11$  (life satisfaction),  $>0.41$  (environmental mastery),  $>0.05$  (positive affect),  $>0.45$  (negative affect), and  $>0.97$  (depression) are significant ( $p < .001$ ) according to Tukey's Studentized range test (honestly significant difference).

<sup>a</sup>Higher scores indicate better ADL independence (ADL Staircase) or perceived functional independence (self-evaluation).

<sup>b</sup>Higher scores indicate higher satisfaction with life (self-evaluation).

<sup>c</sup>Higher scores indicate higher environmental mastery (Ryff scale).

<sup>d</sup>Higher scores indicate stronger affect in this domain (Positive and Negative Affect Schedule).

<sup>e</sup>Higher scores indicate more depressive symptoms (Geriatric Depression Scale).

\*\*\* $p < .001$ .

among multivariate combinations of variables. Canonical correlations parsimoniously describe the number and nature of mutually independent relationships between two different sets of variables, which in this research was the housing variable set and the healthy aging variable set. The housing variable set consists of sum scores or scores on environmental barriers, accessibility, usability, meaning of home, housing-related external control, and housing satisfaction. The healthy aging variable set consists of ADL ranks, and sum score or scores on perceived functional independence, life satisfaction, environmental mastery, depression, and positive as well as negative affect.

The canonical correlation analysis involved successive steps of computing canonical variates for each set of variables. A canonical variate is a linear combination of the variables in each set. The analysis proceeds in a stepwise fashion as follows: First, we compute a pair of canonical variates such that the correlation between them is as large as possible. Next, we calculate a second pair of canonical variates, orthogonal to the first, in the same fashion, and so on. The correlations between the pairs of canonical variates are called the canonical correlations ( $R$ ). The procedure implies that the first  $R$ , extracted in the first step, is the largest; the second  $R$  is the second largest; and so on (for details, see Stevens, 1996; Tatsuoka, 1971; Thorndike, 2000). The analysis should focus on significant canonical correlations only.

To interpret the findings, we focus on the variable loadings. As in factor analysis, a variable's loading is its correlation with the canonical variate (note that a canonical variate is something similar to a factor in a factor analysis). A high loading indicates that the variable is part of the relational pattern expressed by the canonical correlations. Following a suggestion by Tabachnik and Fidell (1989), we do not consider loadings equal to or below the cutoff value of  $r = .35$

for interpretation. In addition, we report the standardized canonical coefficients (for details, see Stevens, 1996; Thorndike, 2000).

We conducted the analysis for each research site separately. To check for similarity of the patterns of relationships found in the different national samples, we used Tucker's coefficient of congruence (Broadbooks & Elmore, 1987) to compare the national samples' loading patterns. The coefficient of congruence is similar to a correlation coefficient, also ranging from  $-1$  to  $1$ ; it was originally designed to compare patterns of factor loadings derived from different samples and is applicable to canonical loadings as well.

## Results

### Descriptive Findings

On the mean level, participants in Eastern European samples (Latvia and Hungary) reported lower scores in life satisfaction and higher scores in depression compared with participants in Western European samples (Sweden, Germany, and the UK). Moreover, in Latvia (but not in Hungary) the environmental mastery sum score was low, which is in contrast to all other national samples. Latvian participants also scored highest in objective independence in ADLs compared with all other participants, and their perceived independence in daily living was lowest compared with all other participants (for details, see Table 2).

### Relationships Between Housing and Healthy Aging

The canonical correlation analysis revealed two significant canonical correlations in all national samples and a third significant  $R$  only in Sweden,

Table 3. Correlations of Aspects on Housing and Healthy Aging (First Canonical Variates)

	Sweden	Germany	UK	Hungary	Latvia
Eigenvalues	1.2***	1.3***	1.6***	1.6***	1.8***
Canonical correlations (%)	.74 (73)	.75 (79)	.78 (74)	.78 (72)	.80 (68)
Housing variable set					
Environmental barriers	-.03 (.15)	-.08 (-.01)	-.09 (.07)	-.21 (.21)	.02 (.12)
Magnitude of accessibility problems	<b>-.73 (-.48)</b>	<b>-.61 (-.30)</b>	<b>-.67 (-.32)</b>	<b>-.69 (-.45)</b>	<b>-.69 (-.34)</b>
Usability in the home					
Physical environmental aspects	<b>.45 (.05)</b>	<b>.42 (.03)</b>	<b>.58 (.09)</b>	<b>.43 (.06)</b>	<b>.36 (.03)</b>
Activity aspects	<b>.64 (.24)</b>	<b>.71 (.35)</b>	<b>.55 (.08)</b>	.27 (.03)	<b>.72 (.28)</b>
Meaning of home					
Behavioral aspects	<b>.81 (.45)</b>	<b>.74 (.38)</b>	<b>.85 (.45)</b>	<b>.82 (.40)</b>	<b>.86 (.36)</b>
Physical aspects	.17 (-.08)	<b>.57 (.17)</b>	<b>.68 (.15)</b>	<b>.63 (.04)</b>	<b>.59 (.03)</b>
Cognitive-emotional aspects	.34 (.18)	.35 (.03)	<b>.45 (.10)</b>	<b>.61 (.19)</b>	<b>.58 (.11)</b>
Social aspects	.30 (-.03)	.13 (-.08)	.35 (-.09)	<b>.46 (-.03)</b>	<b>.52 (.01)</b>
Housing-related ext. control beliefs	<b>-.53 (-.21)</b>	<b>-.58 (-.20)</b>	<b>-.64 (-.33)</b>	<b>-.75 (.34)</b>	<b>-.66 (-.26)</b>
Housing satisfaction	.05 (.06)	.16 (-.03)	.15 (-.09)	.28 (.02)	.08 (.01)
Healthy aging variable set					
Independence in daily activities (ADL)	<b>.83 (.52)</b>	<b>.68 (.37)</b>	<b>.75 (.34)</b>	<b>.68 (.30)</b>	<b>.78 (.37)</b>
Perceived functional independence	<b>.80 (.41)</b>	<b>.76 (.38)</b>	<b>.82 (.37)</b>	<b>.80 (.23)</b>	<b>.87 (.46)</b>
Life satisfaction	<b>.36 (.04)</b>	<b>.50 (.13)</b>	<b>.47 (-.01)</b>	<b>.64 (.08)</b>	.29 (-.07)
Environmental mastery (Ryff)	<b>.59 (.23)</b>	<b>.76 (.45)</b>	<b>.66 (.20)</b>	<b>.84 (.41)</b>	<b>.58 (.18)</b>
Depression (GDS)	<b>-.55 (-.12)</b>	<b>-.53 (.01)</b>	<b>-.76 (-.42)</b>	<b>-.78 (-.24)</b>	<b>-.70 (-.32)</b>
Positive affect (PANAS)	.33 (.05)	<b>.43 (.10)</b>	<b>.39 (.02)</b>	<b>.46 (.09)</b>	<b>.49 (.04)</b>
Negative affect (PANAS)	<b>-.22 (-.06)</b>	<b>-.32 (.01)</b>	<b>-.28 (.06)</b>	<b>-.39 (.01)</b>	<b>-.26 (.04)</b>

Notes: For Sweden, Germany, the UK, Hungary, and Latvia,  $n = 346, 343, 350, 337,$  and  $267,$  respectively. ADL = activity of daily living; GDS = Geriatric Depression Scale; PANAS = Positive and Negative Affect Schedule. Subsamples are reduced as a result of listwise deletion in canonical correlation procedures. Standardized canonical coefficients are shown in parentheses; correlations  $>.35$  are boldfaced.

\*\*\* $p < .001.$

the UK, Hungary, and Latvia. The first canonical correlation in Sweden was  $R = .74$  and accounted for 73% of the overall covariance between housing and healthy aging variables. In Germany the corresponding correlation coefficient was  $R = .75$ , accounting for 79% of the overall covariance; in the UK it was  $R = .78$  (74%); in Hungary,  $R = .78$  (72%); and in Latvia,  $R = .80$  (68%). Loadings and standardized canonical coefficients are reported in Table 3.

The variables with the highest loadings, contributing mostly to the canonical variate in the housing variable set, are behavioral and physical aspects of the meaning of home, the magnitude of accessibility problems, external housing-related control beliefs, as well as activity aspects of usability in the home. Most of these variables correlate above .50 with the canonical variate in all national samples, except for physical aspects of meaning of home in Sweden and activity aspects of usability in Hungary. Moreover, the loadings of physical environmental aspects of usability reach the cutoff value of  $r > .35$  in all samples. Additionally, loadings in cognitive-emotional and social aspects of meaning of home are particularly high in the Eastern but not in the Western European samples. In contrast, the number of environmental barriers and housing satisfaction do not load highly on their canonical variate and thus

are not a part of this relational pattern. In terms of standardized canonical coefficients, however, we found relatively low scores for physical environmental aspects of usability as well as physical, cognitive-emotional, and social aspects of the meaning of home. This indicates some redundancy that is due to correlations of the variables *within* the housing set, meaning that these variables would not contribute substantially to the first canonical correlation, given the other variables in the set, particularly for the behavioral aspects of meaning and activity aspects of usability, at least in Sweden, Germany, and Latvia. Therefore, the first canonical variate in the housing variable set can mainly be characterized by behavioral aspects of the meaning of home, the magnitude of accessibility problems, and low housing-related external control beliefs in all national samples.

In the healthy aging variable set, independence in ADLs and perceived functional independence in daily activities, as well as subjective well-being in terms of environmental mastery and depressive symptoms, load most highly and consistently on the first canonical variate across all national samples. Moreover, positive affect (except for Sweden) and life satisfaction (except for Latvia) reach loadings above the cutoff value of  $r > .35$ , although standardized coefficients in these variables indicate

Table 4. Correlations of Aspects on Housing and Healthy Aging (Second Canonical Variates)

	Sweden	Germany	UK	Hungary	Latvia
Eigenvalues	0.2***	0.2***	0.4***	0.3***	0.8***
Canonical correlations (%)	.42 (13)	.41 (13)	.52 (16)	.50 (15)	.58 (19)
Housing variable set					
Environmental barriers	-.14 (-.12)	-.28 (-.18)	.12 (.15)	.24 (.20)	.12 (.04)
Magnitude of accessibility problems	.15 (.13)	.18 (.27)	<b>.37 (.44)</b>	-.23 (-.43)	-.25 (.37)
Usability in the home					
Physical environmental aspects	.06 (-.15)	.02 (-.14)	.15 (.15)	.18 (.48)	.17 (.17)
Activity aspects	-.12 (-.13)	-.06 (-.24)	-.03 (-.09)	.01 (-.11)	-.24 (-.54)
Meaning of home					
Behavioral aspects	-.07 (-.39)	-.03 (-.22)	-.08 (-.68)	.03 (.42)	.07 (-.29)
Physical aspects	<b>.54 (.31)</b>	<b>.41 (.34)</b>	<b>.51 (.67)</b>	<b>-.54 (-.42)</b>	<b>.47 (.32)</b>
Cognitive-emotional aspects	<b>.61 (.48)</b>	<b>.36 (.18)</b>	<b>.57 (.44)</b>	<b>-.56 (-.37)</b>	<b>.54 (.45)</b>
Social aspects	<b>.52 (.34)</b>	<b>.50 (.40)</b>	<b>.50 (.15)</b>	<b>-.65 (-.48)</b>	<b>.65 (.54)</b>
Housing-related ext. control beliefs	-.35 (-.32)	-.20 (-.21)	-.21 (-.21)	.21 (.05)	-.16 (-.15)
Housing satisfaction	<b>.47 (.39)</b>	<b>.66 (.65)</b>	.25 (.11)	-.01 (.12)	.20 (.02)
Healthy aging variable set					
Independence in daily activities (ADL)	-.27 (.40)	<b>-.54 (-.59)</b>	<b>-.48 (-.59)</b>	<b>.67 (.74)</b>	<b>-.46 (-.55)</b>
Perceived functional independence	-.23 (-.48)	-.29 (-.38)	-.24 (-.32)	.25 (.32)	-.19 (-.28)
Life satisfaction	<b>.36 (.03)</b>	.13 (-.04)	.36 (.11)	-.36 (-.15)	.49 (.14)
Environmental mastery (Ryff)	<b>.51 (.53)</b>	<b>.60 (.78)</b>	<b>.52 (.46)</b>	<b>-.37 (-.43)</b>	<b>.63 (.42)</b>
Depression (GDS)	<b>-.61 (-.60)</b>	-.16 (.04)	<b>-.40 (-.17)</b>	<b>.41 (.48)</b>	<b>-.59 (-.40)</b>
Positive affect (PANAS)	<b>.51 (.31)</b>	.17 (.20)	<b>.47 (.37)</b>	-.05 (.03)	.33 (.14)
Negative affect (PANAS)	-.15 (.16)	<b>-.45 (-.18)</b>	<b>-.47 (-.25)</b>	-.13 (-.16)	<b>-.47 (-.18)</b>

Notes: For Sweden, Germany, the UK, Hungary, and Latvia,  $n = 346, 343, 350, 337,$  and  $267,$  respectively. ADL = activity of daily living; GDS = Geriatric Depression Scale; PANAS = Positive and Negative Affect Schedule. Subsamples are reduced as a result of listwise deletion in canonical correlation procedures. Standardized canonical coefficients are shown in parentheses; correlations  $>.35$  are boldfaced.

\*\*\* $p < .001.$

redundancy given the other variables in the set. Negative affect, however, is not part of the first relational pattern (except for Hungary). Thus, focusing again mainly on the loadings, we find that the first canonical variate in the healthy aging variable set is particularly characterized by observed and perceived independence in daily activities and well-being in terms of environmental mastery, as well as low scores of depression.

In sum, the findings from the first canonical correlation (see Table 3) indicate a pattern of association between housing and healthy aging such that healthy aging in terms of objective and perceived independence in daily activities and subjective well-being in very old age is closely and consistently related to aspects of objective and perceived housing. In other words, participants with a low magnitude of accessibility problems, but not those with low numbers of barriers, who perceive their homes as meaningful on a behavioral level and partially as useful to perform activities and who consider external influences as irrelevant to their current housing situation (low external control), are or perceive themselves to be more independent in daily activities, feel better in terms of environmental mastery, and suffer less from depressive symptoms. Moreover, we found this

pattern across the national samples, suggesting cross-national comparability.

The second canonical correlations also revealed significant patterns of relationships for all national samples; however, the degrees of overall explained variance were considerably low ( $\leq 19\%$ ). The canonical correlation for the second pair of linear composites in Sweden was  $R = .42$  and accounted just for 13% of the overall covariance between housing and healthy aging. In Germany,  $R = .41$  (13%); in the UK,  $R = .52$  (16%); in Hungary,  $R = .50$  (15%); and in Latvia,  $R = .58$  (19%). Loadings and standardized canonical coefficients are reported in detail in Table 4.

Emphasizing only the most consistent findings and highest loadings, the second canonical correlations revealed patterns in which physical, cognitive-emotional, and social meanings of home in all national samples are highly (loadings  $< .35$ ) related to environmental mastery in all samples. Further, these meaning aspects are linked to high amounts of behavioral independence (ADL) in all national samples, except for Sweden, as well as to low levels of depression and high scores of life satisfaction, except for Germany. In addition, negative affect appears with substantial negative loadings in Germany, the UK, and Latvia, and positive affect shows

Table 5. Pairwise Comparisons of Loading Patterns for the Five National Samples

Congruence Scores of Canonical Correlation Loadings	Sweden	Germany	UK	Hungary	Latvia
Sweden	—	0.85	0.91	-0.78	0.91
Germany	0.96	—	0.88	-0.80	0.85
UK	0.97	0.98	—	-0.86	0.97
Hungary	0.91	0.95	0.97	—	-0.85
Latvia	0.97	0.97	0.98	0.95	—

*Notes:* Tucker's coefficients of congruence (Broadbooks & Elmore, 1987) are used. Congruence scores of the first canonical correlation loadings between each research site are listed in the lower left part of the table (i.e. below the diagonal of empty cells); congruences of the second canonical loadings are shown in the upper right part. Because of inverse loading patterns (see Tables 3 and 4), negative scores occur in some national samples.

high positive loadings in the Swedish and the UK samples.

In sum, the findings from the second canonical variate indicate a pattern of association between housing and healthy aging such that nonbehavioral aspects of meaning of home are related to healthy aging in terms of independence in daily activities (except for Sweden) and subjective well-being in terms of environmental mastery, and for some national samples also with depression and affect. In other words, participants who perceive their homes as meaningful as a result of physical, social, or cognitive-emotional aspects tend to be more independent in daily activities, feel better in terms of environmental mastery, and—in some national samples—in terms of positive affect; they also suffer less from depressive symptoms and negative affect.

As one can see in Table 5, the first canonical correlations are highly congruent across the five national samples; that is, this first relational pattern appears rather general and not sample specific, indicating a dominant common pattern of relationships between aspects of housing and healthy aging. In contrast, the second relational pattern comes with lower congruence scores across the national samples and hence comprises more specific aspects of relationships between housing and healthy aging.

## Discussion

This study empirically revealed that objective as well as perceived housing aspects are related to healthy aging in terms of independence in daily activities and well-being in very old age in different urban settings across Europe. Because this array is not well developed conceptually and empirically, we decided to analyze the interrelationships between home and health in an exploratory manner by means of canonical correlations (Stevens, 1996; Tatsuoka, 1971; Thorndike, 2000). We were able to use a rather comprehensive variable set in these analysis, which has not been considered in previous research with such a bandwidth.

Concerning our main research aim, findings

showed that very old participants living in accessible homes, who perceive their home as useful and meaningful on a behavioral level, and who think that others are not responsible for their housing situation are independent in daily activities, have better well-being, and suffer less from depressive symptoms in all five national samples. Besides this main finding, three more specific results are highlighted and discussed in detail in what follows.

A first important result emerging from this research is that it is not the number of barriers in the home environment but rather the magnitude of accessibility problems that is substantially related to different aspects of healthy aging in very old age. The results give further credence to the feasibility of operationalizing housing conditions in a detailed manner, differentiated for environmental barriers as well as accessibility, which is an aspect of P-E fit (Iwarsson, 2005; Iwarsson & Slaug, 2001). Moreover, this finding provides empirical evidence for the ecological theory of aging and P-E fit models in very old age (e.g., Carp, 1987; Kahana, 1982; Lawton & Nahemow, 1973). Concerning the link between accessibility and independence in daily activities, the results were also in accordance with prior findings (Iwarsson, 2005). However, as this study had an explorative approach, further longitudinal analyses are needed to elaborate to what extent health-related outcomes are predicted by housing options and particularly by variations of P-E fit over time (Scheidt & Norris-Baker, 2004).

A second important finding is that both objective and perceived aspects of housing are related to healthy aging. Concerning aspects of perceived housing, particularly behavioral aspects of meaning of home as well as low external control beliefs were closely related to independence in daily life and well-being. In addition (at least in Sweden, Germany, and Latvia), activity aspects of usability are related to healthy aging. In contrast, the global evaluation on housing satisfaction, which is often assessed as the only indicator for perceived housing in other gerontological studies, did not play a major role in the relationship of housing and healthy aging. As was already shown in prior work, perceived usability

and objective accessibility should be closely linked in the home experience (Fänge & Iwarsson, 2003). In addition, the experience of meaningful daily routines and habits (i.e., behavioral aspects of meaning of home) conceptually fits with perceived usability and high levels of access at home (Oswald et al., in press). Thus, the findings are congruent with the assumption that performance of meaningful activities supports independence and health in old age (Clark et al., 1997).

Moreover, psychological processes that are related to the regulation of P–E interchange at home (i.e., control beliefs) are an independent dimension of perceived housing in very old age. In particular, this has been shown with respect to external housing-related control beliefs. Thus, following theoretical assumptions on the role of control beliefs in the domain of housing (Oswald, Wahl, Martin, et al., 2003), the findings underpin the need to consider housing-related control in order to better understand healthy aging in late life. From a methodological viewpoint, the data also underpin the need to address and assess perceived housing comprehensively. On a theoretical level, processes of perceived housing are proved as important facets of the P–E system in later life, adding to a wider holistic understanding of housing and healthy aging (e.g., Oswald & Wahl, 2005; Rowles et al., 2004).

A third important finding from a more general health perspective is empirical support for the assumption that environmental factors are not only related to negative health events, such as falls (Gitlin, 2003), but also to positive health-related outcomes such as independence in daily activities and subjective well-being (e.g., Oswald & Wahl, 2004; Spillman, 2004), as is suggested by the ICF scheme (WHO, 2001) and healthy aging concepts (e.g., Vaillant, 2002). Addressing this relationship in detail, we found that aspects of housing are particularly linked to objective and perceived independence in daily life; this finding was already implied by observations from other studies with very old adults (e.g., Baltes et al., 1999; Iwarsson, 2005), as well as by professional expertise in the field of home modification (AARP, 2005). However, the study also provides evidence that it is not enough for researchers and practitioners to focus merely on a supposed link between housing amenities (e.g., in terms of barriers at home) and daily behavioral independence (e.g., in terms of ADLs and IADLs) when addressing the impact of housing on healthy aging. As was shown, although based on a detailed assessment, it is not the number of barriers but (among other variables) accessibility at home that is linked to behavioral autonomy, and it is not only behavioral autonomy that is linked to various aspects of housing, but also aspects of well-being.

Concerning well-being, it is worth commenting that housing is primarily linked to a strong sense of mastery in managing the environment (Ryff, 1989)

and low levels of depression (Sheik & Yesavage, 1986), but also to global life satisfaction and positive affect, although the latter aspects tend to be redundant given the other variables in the set. That is, in accordance with our assumptions, not only independence in daily activities but also cognitive and emotional aspects of well-being are related to objective and perceived aspects of housing.

Discussing the results of canonical correlations, we should mention that in addition to the results presented, we did compute third canonical correlations as well. Although significant, they explained only minor portions of the overall covariance (between 6% and 8%). Therefore, we did not consider the third covariate as a sufficient basis for additional interpretation of extracted findings. On the cross-national level of data analysis, the congruence of canonical loading patterns indicates that particularly the first canonical variate was highly similar in the five samples studied. Comparable results in this regard can be interpreted in terms of a common pattern of housing and health in very old age, regardless of different objective circumstances in terms of the macro-level environment or differences in the level of life satisfaction or depression between Eastern and Western national samples. However, one needs to consider that participants from different national samples only represent some heterogeneity of cultural differences as a unique quality of the ENABLE–AGE Project. Furthermore, our sample is not representative for the countries included and was limited to urban settings and to those individuals living alone. Thus, further analyses are needed to prove if the relationships remain stable against the background of national policies, norms, and housing programs for older adults in the different countries (Iwarsson et al., 2004).

For the predictive potential of housing aspects for healthy aging to be empirically revealed, longitudinal analyses are needed, emphasizing stability and change in the relationships between housing and healthy aging over time, as well as on subgroup analyses to identify patterns of positive versus negative changes in these relationships. In terms of limitations, these results are restricted to the group of community-dwelling very old people who live alone in urban settings and who were willing to participate in the extensive data collection for the ENABLE–AGE Survey Study. Further research is needed to discover if comparable patterns can be found in other groups of older people (such as those aging in couples) and in other regions (e.g., in rural settings).

Moreover, addressing the relationship of housing and healthy aging always comes with some conceptual overlap between health-related aspects of housing and housing itself, which can be regarded as a limitation of the current study. However, when interpreting our results, one should keep in mind the specific rationale for the choice of housing-related aspects of health and health-related aspects of

housing and the conceptual definition (Iwarsson & Ståhl, 2003) adopted for the ENABLE-AGE Project. Whereas the Housing Enabler captures basic functional limitations in relation to environmental barriers (an aspect of P-E fit), healthy aging is understood as necessary daily activities, assessed by means of the ADL Staircase.

As further steps toward the implementation of these findings in the development of housing interventions and policy, the current focus on barrier-free building standards mainly targeting objective aspects of housing has to be widened to encompass a holistic approach that takes perceived aspects of housing into account as well. Housing and health care professionals need to include housing solutions within a multidisciplinary approach to assessment and care planning. That is, home modification and relocation should not be prescribed but should be negotiated with older adults to take into account their personal needs and preferences. Findings from the ENABLE-AGE Project have potential to encourage authorities to introduce guidelines and regulations to ensure more accessible, usable, and meaningful future housing options for senior citizens.

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