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ORIGINAL INVESTIGATION

The home environment and quality of life-related outcomes in advanced old age: findings of the ENABLE-AGE project

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Abstract With the present research, we further exploited the potential of the ENABLE-AGE Project, more precisely the Swedish and German data. We hypothesised that the magnitude of accessibility problems (MAP) in the home environment and external housing-related control beliefs (HCB) play a substantial role for a range of outcomes related to quality of life. Our sample at T1 consisted of 847 single-living and community-dwelling individuals aged between 80 and 89 years, from urban regions in Sweden and Germany, 636 of whom were re-assessed 1 year later. MAP was measured with the Housing Enabler instrument, while external HCB assessment was based on a questionnaire proved useful in earlier research. Outcomes were assessed with established measures of ADL independence/dependence, general well-being, positive and negative affect and depression. Cross-sectional regressions underscored that MAP and external HCB were rather consistently associated with outcomes, with MAP being more strongly associated with ADL independence/dependence and external HCB more strongly with well-being related outcomes. Furthermore, significant and marginally significant interaction terms underscored that being high in external HCB in the situation of large MAP was linked with more negative outcomes, while external HCB did not play a role in the situation of small MAP. In the longitudinal regression analysis, MAP at T1 was predictive for T1–T2 change in ADL independence/dependence and depression, while external HCB did not show substantial relations with any change in outcomes. Our study underlines and qualifies substantial relations between objective *and* perceived person–physical environment measures and a range of outcomes. Such evidence is required to further improve housing-oriented prevention and intervention strategies in advanced old age.

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Introduction

This article builds on the fundamental assumption of environmental gerontology that the relation of an ageing individual with his or her physical/spatial context is essentially contributing to outcomes that have been identified as crucial for quality of life (Lawton 1991; Wahl and Iwarsson 2007; Walker 2005). In particular, there is reason to assume that the maintenance of independence/dependence in activities of daily life (ADL) and well-being oriented outcomes in later life are related to the utilisation and optimisation of environmental resources such as housing. This becomes especially important for those being more vulnerable because of physical or mental illness. For instance, low mobility capability after a stroke may not affect the autonomy of an individual to reach the third level of a building, if an elevator is available. However, if an elevator is not available, this person's autonomy may be threatened and dependence on the help and support of others may occur. Although such linkage comes with high face validity, the mechanisms at work in person–environment (p–e) interaction as people age deserve additional conceptual and empirical investment. In this paper, we treat some of the enduring conceptual questions inherent in p–e

related ageing research and hope with new data-collection strategies and empirical findings to contribute to their solution.

Open issues of current environmental gerontology and possible solutions

According to Lawton (1999), the objective physical environment covers all that lies outside the skin, is inanimate and is measurable in centimetres, grams, or seconds. The Competence-Press Model, originally suggested by Lawton and Nahemow (1973), provides a broad, overarching framework considering different types and levels of competence such as sensory loss, physical mobility loss, or cognitive decline and physical context factors, including environmental barriers in the area of housing or availability of and distance to public transport. Perhaps the most important element of the Competence-Press Model is its fundamental assumption that for each ageing person there are optimal combinations of (still) available competence and environmental circumstances, leading to the highest possible behavioural and emotional functioning for that person. A term frequently used for this in environmental gerontology is p–e fit (Wahl 2001; Wahl and Gitlin 2007). The model also suggests that it is at the lower levels of competence that older people become the most susceptible to their environment such that low competence in conjunction with high "environmental press" impacts negatively on outcomes such as ADL independence/dependence and well-being.

One remaining conceptual and empirical issue of debate in the context of the Competence-Press Model is whether competence and environmental press should be considered separately or in an integrated, i.e. more interactional, manner. Separate assessment of the person and the physical environment's characteristics has been the rule in the traditional environmental gerontology and architectural and design literature. Typically, data from an objective assessment of environmental barriers in the home environment have been correlated with any kind of outcome data most typically drawn from a range of ADL related indicators. Although this kind of research is able to nurture to some extent the assumption that more environmental barriers are associated with ADL independence/dependence, findings have remained inconsistent both in the non-intervention and intervention oriented research (see literature review by Wahl et al. 2009). A plausible explanation for this inconsistency is that there has been a tendency in the previous research to combine all kinds and severity grades of competence loss with all kinds and magnitudes of environmental barriers side-by side, which may have blurred the impact of p–e relations on ADL independence/dependence in later life (Wahl et al. 2009; Wahl and Gitlin 2007).

A better way to consider the role of objective p–e relationships may thus be to refer to conceptual approaches which are able to directly grasp the interactional component between functional limitations of the person and environmental barriers in terms of p–e fit or lack of p–e fit. A concept introduced in the recent years in the ecology of ageing and occupational therapy literature, able to contribute to such an ambition, is accessibility (Iwarsson and Ståhl 2003; Wahl and Iwarsson 2007). Accessibility is defined as a relative concept, that is, environmental barriers always deserve consideration in the light of the profile of functional limitations of the ageing person in question and vice versa. Further, a reliable and valid assessment tool, the Housing Enabler, has been introduced for empirical translation of the concept, i.e. the measurement of magnitude of accessibility problems (MAP) (Iwarsson and Slaug 2001). In several publications based on the ENABLE-AGE Project (e.g. Oswald et al. 2007) we have simultaneously considered the MAP and the number of environmental barriers in the home environment. As was found, the number of environmental barriers completely lost its statistical importance for outcomes such as ADL independence/dependence when MAP was included as a predictor variable. This was true regardless of the socio-structural context under consideration (West versus East European countries, in particular) and therefore seems to be a rather robust finding. Therefore, we conclude that an important methodological requirement of successfully using the Competence-Press Model for empirical environmental gerontology research is the consideration of MAP.

More specifically, we assume, in accordance with previous research, that MAP should reveal substantial relations with ADL independence/dependence. Because functional limitations have been found to be substantially associated with ADL independence/dependence (e.g. Guralnik et al. 2000), this relation should become even stronger, if reduced functional limitations are considered in conjunction with unfavourable physical environmental circumstances. MAP may also reveal linkages with well-being related outcomes (Werngren-Elgström et al. 2009), because low accessibility may come with lowered attainment of desired life goals (such as staying put as long as possible) and thus impact on life satisfaction, affect, and depression. Generally, however, we expect that the relationship of MAP with performance in activities of daily living should be more substantial as compared with well-being related outcomes, because the latter causal linkage is probably more indirect and unspecific.

Another issue of conceptual and empirical debate is that the original Competence-Press Model leaves a too weak

and reactive role to the ageing individual as a producer of its own p–e development (Wahl and Oswald 2009). Thus, Lawton (1989) introduced the concept of p–e proactivity and argued that particularly highly competent ageing individuals still are well able to shape their physical environment and purposefully improve their p–e fit, for instance in housing. However, the concept of p–e proactivity has so far not found much attention in the empirical research literature. One possibility to address p–e proactivity can be found in Oswald et al. (2007a, b) and Oswald et al. (2007a, b) work on housing-related control beliefs (HCB) (Oswald et al. 2003). As was argued by these authors, introducing a domain-specific control belief dimension which targets a major sphere of ageing, i.e. housing, may help to better understand how ageing individuals deal with the challenges of their physical living arrangements and why housing-related outcomes reveal pronounced diversity as people age.

In the present study, following-up our previous research (Oswald et al. 2007a, b), we expect that HCB is important to consider in combination with MAP, because they conceptually and empirically add to each other. While MAP focuses on objective p–e relations, HCB highlights a major component of perceived and experiential linkages of ageing individuals with their home context. More specifically, we expect that the stronger an older individual believes that housing-related issues are not under her/his own control (external HCB), the lower his or her ADL independence and well-being. Regarding ADL independence, the experience of not being in control of the home environment may lead to the underutilisation of available options (e.g. home modification) toward supporting independent functioning. Since the home environment is a, if not the major context of ageing (Baltes et al. 1999; Wahl and Oswald2009), we expect a still stronger negative effect of HCB on well-being than on ADL independence, particularly when external HCB are high. For example, the belief that the housing context is beyond one's own control may lead to stress and pronounced negative future expectations such as the anticipation of possible forced relocation to an institutional context.

In addition, we assume that HCB and MAP interact and that such interaction also relates to outcomes. That is, living in a situation of large MAP and being at the same time high in external HCB may reveal negative outcomes, because the impact of pronounced objective lack of fit between competence and environmental press may be intensified by the perception that attempts to modify/optimise one's home environment are subject to uncontrollable external forces. In contrast, if MAP is low, being high in external HCB may not be that important, because overall independence still is rather high.

Goals and hypotheses

First, we target the linkages between MAP as well as HCB and a range of outcomes including ADL independence/dependence, emotional and cognitive well-being, and depression. We hypothesise that MAP as well as HCB are important for such outcomes, but that MAP will be more important for ADL independence/dependence, whereas HCB will be more important for well-being related outcomes. Going further, we expect that higher MAP will be associated with more ADL dependence and less positive well-being-related outcomes.

Second, we analyse whether possible change in outcomes over 1 year is linked with MAP and HCB at baseline. However, because well-being outcomes most likely will not show much variability over a short observation period (e.g. Smith et al. 1999), whereas now classic work has shown that ADL independence/dependence will, particularly in advanced age (Wolinsky et al. 1996), we expect that MAP and possibly also HCB will reveal a substantial relation with change in ADL independence/dependence, but not so much with well-being. More specifically, we expect that large MAP and high external HCB at T1 will be associated with decreasing ADL independence.

In addition, we do not only expect a main effect of MAP and external HCB on ADL independence/dependence and well-being, but also a statistically meaningful *interaction* operating between MAP and external HCB, when it comes to the prediction of ADL independence/dependence and well-being related outcomes. That is, we assume that the combination of high MAP and high external HCB further increases the risk for negative outcomes, while external HCB should not play a role if MAP is low.

Method

Design and study sample

We used the data gathered in Sweden and Germany as part of the ENABLE-AGE Project (Iwarsson et al. 2007a, b) to test our hypotheses. The primary reason for this is that participants were drawn at random from official national registers in a highly similar way in Sweden and Germany. Because ENABLE-AGE was particularly interested in very old and vulnerable individuals, only community dwelling elders aged between 80 and 89 years, living alone in urban areas (in Lund, Helsingborg and Halmstad municipalities in Sweden; the region of Heidelberg-Mannheim in Germany) were included (Table 1).

As can be seen in Table 1, the final sample comprised $N = 397$ (Sweden) and $N = 450$ (Germany), amounting to

Table 1 Sample description ($N = 847$)

Variable	Sweden ($n = 397$)	Germany ($n = 450$)	Differences
Age (M, SD)	84.6 (3.1)	85.1 (3.2)	n.s.
Sex (% women)	74.6%	78.4%	n.s.
Education (year of schooling) (M, SD)	8.8 (2.2)	11.6 (2.6)	***
Income/month in € (M, SD)[a]	1,015 (410)	1,569 (799)	***
Evaluation of financial resources (%, *n*) as:			
Low	34.4 (130)	17.4 (76)	
Average	54.5 (206)	73.3 (321)	***
High	11.1 (42)	9.4 (41)	
Perceived health (1–5)[b]	2.8 (1.1)	3.6 (0.8)	***

Test for differences: *n.s.* not significant, ***$P < 0.001$

[a] In total 156 participants (18.4%) did not give information on income per month

[b] Five point Likert type scale from "very good" (1) to "bad" (5)

a total of $N = 847$ individuals in advanced old age at the first survey data collection occasion (T1). The refusal rates were 58.9% in Sweden and 61.7% in Germany. The major reasons behind these fairly high refusal rates probably are that community-dwelling very old persons who live alone are considered to be very sensitive and vulnerable concerning extensive external contact with researchers. In both countries, the most important reasons for refusal were "lack of interest or time" (S: 35.7%; G: 61.4%), "poor health" (S: 27.1%; G: 24.1%), "interview too stressful" (S: 17.8%; G: 7.6%), and "distrust/fear" (S: 11.6%; G: 4.1%). There were differences between the Swedish and German sample in income (higher in Germany) and education level (more years in Germany). At the same time, the German sample appeared more unfavourable regarding perceived health.

At the second survey data collection occasion (T2; 1 year after T1) the samples reduced to $N = 314$ (79.1%) in Sweden and $N = 322$ (71.2%) in Germany, an expected shrinkage in the age group at target, in both countries mostly due to illness (S: 6.8%; G: 6.7%), death (S: 22.0%; G: 18.3%), and inability to contact (S: 71.2%; G: 75.0%) because of unknown relocation or other reasons.

Measures

Magnitude of accessibility problems

MAP was assessed by means of the Housing Enabler (Iwarsson and Slaug 2001). The instrument has proved to be valid and reliable in previous research (Fänge and Iwarsson 2003; Iwarsson and Isacsson 1997). For this study, a cross-national research version considering partially different legal norms of housing environments in the five countries taking part in the ENABLE-AGE Project was developed and tested, reaching sufficient inter-rater reliability (Iwarsson et al. 2005).

The instrument is administered in three steps by trained occupational therapists. The first step is the dichotomous assessment of functional limitations (13 items foremost covering mobility, but also perception and to some extent cognition) and dependence on mobility devices (2 items; e.g. wheelchair use) according to "present" or "not present". This part of the assessment reflects the personal component of p–e fit, based on a combination of interview and observation. The second step is the assessment of physical environmental barriers, i.e. the environmental component of p–e fit. This is a detailed observation assessing environmental barriers in the home and the immediate outdoor environment (188 items) as present or absent. The housing environment is divided into four sections: outdoor environment (33 items), entrances (49 items), indoor environment (100 items), and communication features (6 items), which all contribute to the calculation of a total score used in the present study. That is, in a the third step, a total p–e fit score is calculated: For each environmental barrier item, the instrument comprises predefined severity ratings based on previous research as well as practical evidence (Steinfeld et al. 1979), operationalised as points quantifying the severity of the p–e fit/accessibility problems in each case. The accessibility severity scale is scored 1 to 4, from 1 (potential accessibility problem) to 4 (very severe accessibility problem or impossibility). On the basis of the assessments accomplished in steps 1 and 2, with use of a two-dimensional matrix comprising the predefined severity ratings from 1 to 4, the profile of functional limitations identified in each person is juxtaposed with the environmental barriers found present in the home environment. This computerised analysis is run item by item, and all the predefined points are summed to a p–e fit score with higher scores indicating higher MAP (Iwarsson and Isacsson 1996). The theoretical maximum score is approximately 2,500; in the current study, the maximum score was 596. In cases in which no functional limitations or dependence on mobility devices are present, the score is always zero, whereas in cases in which the person has any kind of functional limitations, higher scores mean more p–e fit problems.

Housing-related control beliefs

HCB were assessed with the 24-item housing-related self evaluation control beliefs questionnaire, based on the dimensions of "internal control" (8 items, sum-score), "external control: powerful others" (8 items, sum-score), "external control: chance" (8 items, sum-score) (1–5) (Oswald et al. 2003). "Internal control" means that housing-related events are highly contingent upon a person's own behaviour, where personal responsibility implies that one is responsible for what happens. "External control" means either some other person is responsible or things happen by mere luck, chance, or fate. In the present study, the internal control component was not considered, because conceptually external HCB were of particular interest. The internal consistency of the internal scale also appeared as rather low, which gave an empirical argument for removing this scale from our analyses. Further, there was a need to combine both external sub-scales in order to achieve sufficient reliability, resulting in a 16-item scale (internal consistency including both countries: $\alpha = 0.72$). Because control beliefs generally are regarded since the inception of the construct as possessing a strong dispositional component (Rotter 1966), HCB were assessed only at T1.

Outcomes

ADL Independence/dependence was assessed by means of the ADL Staircase (Sonn and Hulter-Åsberg 1991). This instrument is an extension of Katz's ADL Index (Katz et al. 1963), comprising five personal activities of daily living (P-ADL) items, i.e. feeding, transfer, going to the toilet, dressing, bathing, and four instrumental ADL (I-ADL) items, i.e. cooking, shopping, cleaning, and transportation. The ADL Staircase is administered as a combination of interview and observation, and the assessment is recorded on a three-graded scale: independent, partly dependent, and dependent. Validity and reliability of the instrument have been demonstrated with community-living older people in previous research in Sweden (Iwarsson 2005; Iwarsson and Isacsson 1997; Sonn and Hulter-Åsberg 1991). We used in the present study only the total sum score of P-ADL and I-ADL carried out independently.

Subjective well-being comprises cognitive and emotional aspects. Life satisfaction, as the cognitive component, was assessed by means of a single item self evaluation measure (0–10), also used in the ongoing German survey study Socio-economic Panel (e.g. Schilling 2005).

Affect was assessed by means of the Positive and Negative Affect Schedule (PANAS; Watson et al. 1988), generating a score for negative and positive affects, consistently shown to be independent from each other (Watson and Clark 1997; Staudinger et al. 1999). Participants were instructed to judge how frequently they had experienced 20 different emotions during the previous year (1–5). Examples of positive affect items (10 items) are interested, excited, strong, active, inspired, while distressed, guilty, nervous afraid, ashamed are examples of negative affects (10 items). Overall internal consistency for the positive affect sum-score was $\alpha = 0.76$, and for negative affect sum-score $\alpha = 0.78$.

Depression was assessed 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?" (overall internal consistency, $\alpha = 0.82$). All outcomes were assessed both at T1 and T2.

Procedure

After intensive training of project assistants (occupational therapists) in both countries and accomplishment of the inter-rater reliability study (Iwarsson et al. 2005), data were collected at home visits. Involving occupational therapists in the data-collection process was regarded as important, because for a major part of the assessments administered in this survey study occupational therapy expertise is an ideal precondition (Iwarsson et al. 2004). Intended participants were consecutively included from sampling lists, via mailed letters followed by phone calls. All participants were enrolled after informed consent, following the ethical guidelines and procedures of each country.

Data-analytic design

Descriptive data analysis started with means and SD's both at T1 and T2. Descriptive analysis of relationships were based on zero-order correlations of study variables, whereas hypothesis testing relied on regression analysis, in which MAP and external HCB served as independent variables. We also included an interaction term MAP × HCB, because such an interaction was theoretically expected. To avoid multicollinearity problems, predictors were centred (Aiken and West 1991). In the regression analyses targeting T1–T2 change in outcomes, we used change scores as dependent variables and status at T1 in MAP and external HCB as independent variables. In addition, we controlled for possible confounders at T1 (age, sex, perceived health). We also controlled in the regression analyses for the role of country, because we had identified some sampling and socio-structural differences between the Swedish and German sample.

Table 2 Descriptive data of study variables

Variables M (SD)	Sweden (T1) ($n = 397$)	Germany (T1) ($n = 450$)	Sweden (T2) ($n = 314$)	Germany (T2) ($n = 322$)
Magnitude of accessibility problems (0–596)[a]	148 (126)	148 (122)	143 (126)	150 (131)
External housing-related control beliefs (1–5)[b]	2.8 (0.5)	2.8 (0.7)	–	–
ADL independence/dependence (0–9)[c]	7.6 (1.5)	7.8 (1.4)	7.6 (1.7)	7.6 (1.5)
Life satisfaction (0–10)[d]	8.5 (1.7)	8.5 (1.8)	8.6 (1.7)	8.1 (1.9)
Positive affect (1–5)[e]	3.2 (0.6)	3.4 (0.7)	3.1 (0.6)	3.4 (0.6)
Negative affect (1–5)[e]	2.0 (0.5)	2.0 (0.6)	2.1 (0.5)	2.0 (0.6)
Depression (GDS) (0–15)[f]	3.0 (2.3)	3.2 (2.9)	3.4 (3.4)	3.7 (3.0)

[a] Higher scores indicate larger magnitude of accessibility problems

[b] Higher scores indicate stronger external housing-related control beliefs; only assessed at T1

[c] Higher scores indicate higher ADL independence

[d] Higher scores indicate higher life satisfaction

[e] Higher scores indicate higher positive and negative affect

[f] Higher scores indicate higher depression

Table 3 Bivariate correlations between study variables for Sweden ($N = 397$) and Germany ($N = 450$)

Pearson correlations (r)	MAP	Ext. HCB	ADL	LS	PA	NA	D
Magnitude of accessibility problems (MAP)	–	0.27***	−0.45***	−0.17**	−0.20***	0.06	0.26***
External housing related control beliefs (Ext. HCB)	0.27***	–	−0.27***	−0.14**	−0.29***	0.09	0.26***
ADL independence/dependence (ADL)	−0.41***	−0.31***	–	0.21***	0.20***	−0.06	−0.30***
Life satisfaction (LS)	−0.23***	−0.17***	0.15**	–	0.31***	−0.25***	−0.47***
Positive affect (PA)	−0.24***	−0.25***	0.24***	0.36***	–	0.00	−0.41***
Negative affect (NA)	0.13**	0.21***	−0.05	−0.30***	−0.07	–	0.31***
Depression (D)	0.26***	0.26***	−0.30***	−0.46***	−0.42***	0.39***	–

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$. Correlations for Germany are listed in the lower left part of the table (i.e. below the diagonal of empty cells), for Sweden are shown in the upper right par

Results

A descriptive comparison of the study variables showed that there were basically no differences between Swedish and German participants at T1. As it is depicted in Table 2, particularly MAP and external HCB were nearly identical in both sites at T1, and MAP was also rather similar at T2. In addition, all outcome variables were comparable at T1 and T2. Moreover (not listed in Table 2), differences on the mean level between T1 and T2 did not appear for MAP and for negative affect in any country. Positive affect changed (i.e. decreased) significantly only in Sweden and life satisfaction changed (i.e. decreased) significantly only in Germany, whereas there was a significant increase in depressive symptoms in both sites between T1 and T2.

Zero-order correlations between study variables are presented in Table 3. As can be seen, only small to medium correlations occurred between both, MAP and external HCB on the one hand and outcomes on the other, with strongest links between MAP and ADL dependence/independence in both settings ($r = -0.45$ in Sweden and $r = -0.41$ in Germany) and weakest links between MAP and negative affect ($r = 0.06$ in Sweden and $r = 0.13$ in Germany). That is, correlation sizes were highly similar in magnitude in both samples. Links between MAP and external HCB were on a medium level and identical in both samples ($r = 0.27$).

Results of cross-sectional regression analyses are presented in Table 4. Concerning the confounding variables, age became significant when predicting ADL dependence/independence. Sex also made a difference, not only in predicting ADL dependence/independence (lower in women), but also for positive affect, such that men had higher scores compared to women, whereas being a woman predicted slightly higher negative affect scores. Better perceived health was linked to higher life satisfaction,

Table 4 Findings of regression analyses (cross-sectional analyses at T1, $N = 847$)

Predicting variable	ADL independence/ dependence		Life satisfaction		Positive affect		Negative affect		Depression	
	Stand. β	Semi-artial[c] R^2	Stand. β	Semi-partial R^2	Stand. β	Semi-partial R^2	Stand. β	Semi-partial R^2	Stand. β	Semi-partial R^2
Country (Germany = 0; Sweden = 1)	−0.048	0.002	−0.102*	0.008	−0.24***	0.049	0.083*	0.006	0.085*	0.006
Age	−0.111**	0.011	0.044	0.000	−0.013	0.000	−0.023	0.000	0.003	0.000
Sex (f = 0, m = 1)	0.118***	0.013	0.054	0.000	0.133***	0.018	0.091*	0.008	-0.023	0.001
Perceived health (1–5)	−0.022	0.000	−0.282***	0.070	−0.263***	0.049	0.108*	0.008	0.315***	0.071
Magnitude of Accessibility Problems (MAP) (0–596)[a]	−0.342***	0.088	−0.077(*)	0.007	−0.076(*)	0.004	0.028	0.000	0.098*	0.007
External housing related control beliefs (ext. HCB) (1-5)[b]	−0.156***	0.021	−0.088*	0.025	−0.145***	0.025	0.129**	0.015	0.167***	0.025
Interaction MAP × Ext. HCB	−0.059(*)	0.003	−0.042	0.011	−0.024	0.000	0.015	0.000	0.107**	0.011
Model R^2	0.23		0.11		0.16		0.05		0.18	

Project ENABLE-AGE, T1, $N = 847$ (Sweden, Germany), with (*)$p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

[a] Higher scores indicate larger magnitude of accessibility problems

[b] Higher scores indicate higher external housing related control beliefs

[c] Proportion of the dependent variable's total variance explained by regression on the predictor *uniquely*; not to sum up to the model's total R^2

positive affect and lower depression scores. The importance to also control in these analyses for country was particularly supported in case of the well-being related outcomes.

As our study variables are concerned, Table 4 shows that both MAP and external HCB revealed as important predictors for the outcomes. According to the explained variance of the models, overall the set of predictors best explained ADL dependence/independence (23%), followed by depression (18%), positive affect (16%), life satisfaction (11%), and, on a clearly lower level, negative affect (5%). As the semi-partial *R*-squares underscore and as expected, MAP was more strongly linked with ADL dependence/independence, whereas external HCB was more strongly associated with subjective well-being indicators. However, external HCB also significantly contributed to the explanation of ADL dependence/independence, while MAP was also statistically linked with life satisfaction, positive affect and depression. All relations appeared in the expected direction, that is, a higher MAP was linked with more ADL dependence, lower life satisfaction, lower positive affect, and higher depression. Similarly, higher external HCB were associated with more ADL dependence, lower life satisfaction, lower positive affect, higher negative affect, and higher depression.

Furthermore, as is indicated by a significant effect of the interaction between MAP × external HCB, the predictive role of MAP and external HCB on depression amplified with increasing amounts of MAP *and* external HCB and decreased with low MAP and low external HCB. In other words, if a participant experienced high MAP and felt that others were responsible for his or her own home environment, this came with an increase of depression and vice versa. Similarly, but only marginally significant, individuals high in MAP and high in external HCB revealed lower ADL independence, which was less the case for participants in home situations with high MAP and reporting to be low in external HCB. These interactive effects are further illustrated in Fig. 1, showing regression lines predicting depression and ADL independence from MAP under varying levels of external HCB. That is, Fig. 1 visualizes how the impact of *objective* lack of fit between competence and environmental press on depression and ADL independence is intensified by the perception that attempts to modify/optimise one's home environment are subject to uncontrollable external forces.

Findings of regression analyses including T1–T2 change in outcomes are depicted in Table 5. As can be seen in Table 5, the MAP at T1 was able to predict change towards more ADL dependence as well as increase of depression from T1 to T2, whereas external HCB at T1 was not. However, we found significant effects of the interaction between MAP and external HCB regarding life satisfaction and depression. These significant interactions mean that the

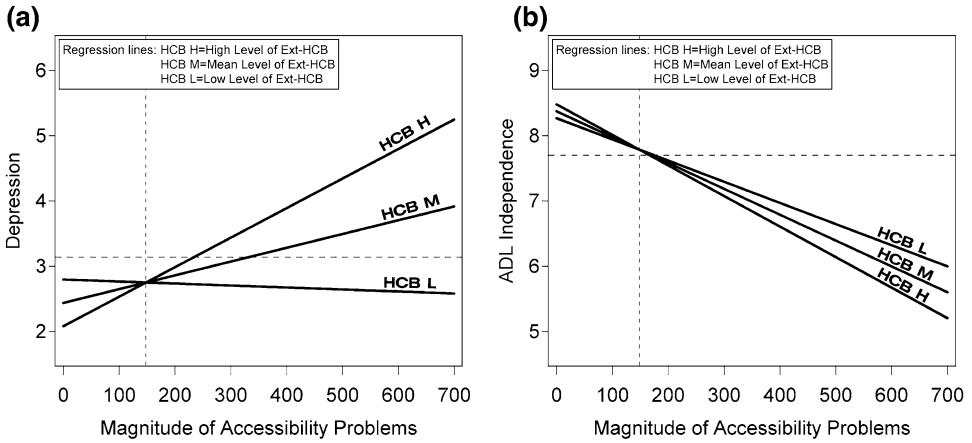

Fig. 1 Illustration of Interaction Effects between Magnitude of Accessibility Problems, External Housing-related Control Beliefs and Depression and ADL Independence. *HCB* External Housing-related Control Beliefs. Figure shows regression lines predicting the outcome from MAP, which result due to the estimated interaction coefficients under selected levels of HCB, namely if HCB is at mean level (HCB M) and one standard deviation above (HCB H) or below (HCB L) its mean level

predictive role of MAP on changes in life satisfaction and depression declines with increasing levels of external HCB and amplifies with *decreasing* external control beliefs. In other words, if a participant lived in a situation with pronounced lack of p–e fit and at the same time felt that others are responsible for his or her own home environment, this seemed to lead to an *increase* of depression and decrease in life satisfaction, whereas participants high in MAP and at the same time not feeling themselves responsible for their own home were not so much at risk for an increase of depressive symptoms and lowered life satisfaction. Finally, the potential confounders did not play a role in T1–T2 relationships.

Discussion

Although the role of the physical environment for ageing individuals has been frequently underlined in the recent literature (e.g. Wahl and Iwarsson 2007; Wahl et al. 2007) and even has become part of some of the well-established measurement devices aimed to assess quality of life (e.g.

Table 5 Findings of regression analyses (longitudinal analyses considering 1-year change in outcomes, $N = 636$)

Predicting variable	ADL independence/ dependence		Life satisfaction		Positive affect (PANAS)		Negative affect (PANAS)		Depression (GDS)	
	Stand. β	Semi-partial[c] R^2	Stand. β	Semi-partial R^2	Stand. β	Semi-partial R^2	Stand. β	Semi-partial R^2	Stand. β	Semi-partial R^2
Country (Germany = 0; Sweden = 1)	−0.033	0.000	0.088(*)	0.006	−0.076	0.005	0.078	0.005	0.012	0.000
Age	−0.034	0.001	0.010	0.000	−0.077	0.005	−0.010	0.002	0.039	0.001
Sex (f = 0, m = 1)	−0.069	0.005	−0.056	0.003	0.018	0.000	0.053	0.003	0.046	0.002
Perceived health (1-5)	−0.50	0.001	−0.000	0.000	0.087(*)	0.005	0.049	0.002	−0.059	0.003
Magnitude of accessibility problems (MAP) (0-596)[a]	−0.252***	0.048	−0.051	0.002	−0.016	0.000	−0.010	0.000	0.134**	0.014
External housing related control beliefs (Ext. HCB) (1-5)[b]	0.064	0.004	0.051	0.002	−0.007	0.000	0.005	0.000	0.017	0.000
Interaction MAP × ext. HCB	0.030	0.000	0.104*	0.011	−0.013	0.000	−0.005	0.000	−0.112*	0.012
Model R^2	0.08		0.02		0.02		0.01		0.04	

Project ENABLE-AGE, T2, N = 636 (Sweden, Germany), with (*)$p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

[a] Higher scores indicate larger magnitude of accessibility problems

[b] Higher scores indicate higher external housing related control beliefs

[c] Proportion of the dependent variable's total variance explained by regression on the predictor *uniquely*; not to sum up to the model's total R^2

Steinbüchel et al. 2006), theory-driven empirical work in the area has remained rather rare (Scheidt and Windley 2006; Wahl and Oswald 2009). In particular, using the Competence-Press Model (Lawton and Nahemow 1973) as a driving force for exploring the role of the home environment for the process of ageing has been done in a surprisingly unsystematic manner and without much sustainable consequences in terms of methodology (Scheidt and Windley 2006).

In the present study, we further exploited the potential of the ENABLE-AGE data set to, address two research issues. Utilising the Swedish and German data available, we were interested in the cross-sectional and longitudinal role of MAP and external HCB for a wide range of outcomes including ADL independence/dependence, cognitive and affective well-being and depression.

On the cross-sectional level, largely confirming previous research (Oswald et al. 2007a, b; Werngren-Elgström et al. 2009), we found as hypothesised that MAP was consistently related with ADL independence/dependence as well as life satisfaction, positive affect, and depression. Larger MAP was linked with more unpleasant outcomes and the relative contribution of MAP to the explanation of outcome variation was highest, as predicted, with respect to ADL independence/dependence. External HCB were as well consistently linked with all outcomes, but particularly strongly, as we expected, with the well-being related measures.

Furthermore, the interaction of MAP with external HCB reached statistical significance in case of depression and was marginally statistically significant also in respect of ADL independence/dependence. This provides at least some support for our expectation that the combined consideration of MAP (as representing the objective p–e relation) and HCB (representing a major component of the perceived and experiential component of the p–e relation) comes with a conceptual and empirical added value. That is, it seems that high external HCB is able to aggravate the impact of a large MAP on depression and, to a lesser extent, on ADL independence/dependence, while this is not true, if MAP is low. This adds to insights of previous research based on the ENABLE-AGE data considering external HCB (Oswald et al. 2007a, b).

All these findings hold after controlling for age, gender and perceived health. As could be expected based on previous research (e.g. Staudinger et al. 1999; Wolinsky et al. 1996), higher age was predictive for lowered ADL independence only, while lower perceived health was linked with lower life satisfaction, lower positive effect and higher depression, and marginally also with higher negative affect. Gender also was predictive, i.e. women revealed lower ADL independence, lower positive affect and higher negative affect.

In sum, we regard the findings on p–e fit, or accessibility, in line with our conceptual argumentation, in which we have predicted that high MAP are predominantly linked with loss in the ability to perform activities of daily living independently. Well-being outcomes may be also caused by MAP because lowered accessibility may threaten or block important life goals such as staying put as long as possible, and our findings support this notion, The reason why this relationship was not found with regard to negative affect may be that negative affect has generally revealed strong linkage with personality-related components such as neuroticism, but not so much with situation-specific characteristics (Baker et al. 1992; Clark and Watson 1991). Our results with regard to external HCB also underscore the heuristic fruitfulness of operationalising p–e proactivity in terms of a physical home environment oriented domain-specific control construct. Because the housing area plays such a prominent role in the vulnerable period of very old age (e.g. Gitlin 2007; Wahl and Oswald2009; Wahl and Gitlin 2007), it seems logical that having developed over one's lifetime the disposition of external control with regard to housing will cause deterioration in cognitive and emotional well-being. Although less important as MAP, high external HCB also predicted ADL independence/dependence and a possible causal mechanism may be, as we have conceptually argued, that being high in external HCB comes with reduced proactivity as concerns, e.g. home modification. High external HCB also revealed a statistically significant relation with negative affect, which may be due to a possible association between external HCB and neuroticism, a personality trait closely linked with negative affect (Clark and Watson 1991; see also De Beurs et al. 2005).

With our second research aim, we attempted to test our study assumptions also in a prospective perspective, though the observation interval of 12 months was short and change was not very likely, particularly with respect to the well-being related outcomes. Still, staying put in your familiar home over 1 year could be considered as a considerable period of time for people aged between 80 and 89 years. As was found, MAP revealed as a significant predictor for change in ADL independence/dependence, but also for depression. This is remarkable, because practically none of our control variables considered at T1 in addition to MAP and external HCB played a predictive role.

We thus conclude that large MAP at a given point in advanced old age contributes to decreases in ADL independence as well as increases in depression across a rather short period of time. However, the amount of explained variance was generally small, particularly in the case of depression, and thus the evidence is limited in terms of strength and robustness. Moreover, we found in the longitudinal analysis that individuals high in MAP and low in

external HCB at T1 showed greater loss in life satisfaction and greater increase in depression over time as compared to those with large MAP and high external HCB. Because the overall amount of explained variance and the semi-partial R^2's were quite low both in life satisfaction and depression, we hesitate to invest much in the interpretation of this unexpected direction of the interaction. Nevertheless, a possible explanation may be that, as compared to our cross-sectional findings, in the longer run it may be more adaptive, being confronted with a high MAP in advanced old age, to rate one's influence on future housing as limited, because environmental change becomes increasingly difficult.

Regarding application, our findings provide additional support for the importance of providing effective rehabilitation in very old age, in order to maintain and optimise personal competencies as well as the reducing environmental barriers in the home context (Gitlin 2007; Wahl et al. 2009). That is, early intervention aiming at reducing MAP has the potential to reduce very old people's need for support in ADL in the longer run (Iwarsson et al. 2007). That is, home modification has a preventive potential and should therefore be introduced early in the process of functional decline. Such interventions are positive not only from an individual perspective but also from a societal point of view.

A major limitation of this study is that is does not allow comparison with other (younger or older) age groups, because of the restricted age range inherent in our study design. Also, our sample is an urban one and therefore the generalization to rural regions is limited. Another limitation is the rather short time interval between T1 and T2, which was too short to expect substantial change in some of our outcomes, particularly those linked with well-being. Therefore, our findings regarding the relationship of MAP and external HCB and change in well-being should be treated with caution.

In sum, by exploiting a data-set containing probably the soundest measurement of p–e dynamics in advanced old age available at present, this study underlines and qualifies the existence of substantial relations between objective *and* perceived person–physical environment and a wide range of outcomes including ADL independence/dependence and well-being. Ongoing research based on the ENABLE-AGE project includes longer observation intervals and considers additional variables such as meaning of home (Oswald and Wahl 2005) and perceived usability of the home environment (Fänge and Iwarsson 2005). Also needed are controlled intervention studies, in which person–physical environment constellations are systematically altered and checked for their combined effects on various outcomes important for the quality of life of very old adults (Wahl et al. 2009).

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