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The Impact of Adults' Used Skills on Their Self-Evaluated Skills and Social Lives Over Time

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Abstract: Previous research focused on individuals' background, contexts and cognitive performance in education, work, and life. Given the increasing number of people living alone temporarily, the question arises whether the frequent use of skills, including social skills, relates to individuals' later positively self-evaluated skills and social lives. Based on an integrated framework, the current analysis aimed to disentangle these relationships with longitudinal data from Germany over three years. The target sample consisted of n = 3263 working adults. A Bayesian structural equation model included adults' frequent use of skills, self-evaluated skills, household size, close friends, and seven covariates (e.g., numeracy and literacy test scores, weekly working hours. The results suggested positive relationships between adults' frequent use of numeracy, literacy, and social skills and later self-evaluations (except literacy used on self-evaluated numeracy). Those who less frequently used social skills three years earlier were also less likely to have a larger household size than those who reporting frequently using their social skills. Adults who frequently used literacy skills three years earlier reported higher numbers of close friends than those who less frequently used literacy. The findings highlight the importance of adults' social skills and frequently used skills for self-evaluated numeracy and literacy.

Keywords: *Adults, frequently used skills, literacy, numeracy, PIAAC-L, social lives.*

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Introduction

There are ongoing scientific and public debates in our society on whether adults' frequently used skills relate to their self-evaluation and social environment (Broadbent & Mareschal, 2019; Brun-Schammé & Rey, 2021; Choi et al., 2020; Crusius et al., 2022; Santiago-Vela & Hall, 2022; Zell et al., 2020). Vocational educational, higher educational, occupational, and leisure contexts frequently require numeracy, literacy, and social skills of adults (Organization for Economic Co-operation and Development [OECD], 2021). However, there is scant evidence on whether frequently used skills relate to adult's later self-evaluation by social comparisons, and to their social environment. The current research aimed to shed some light into these complex relationships based on established skill frameworks (OECD, 2021), social comparison theory (Crusius et al., 2022; Festinger, 1954) and neuroconstructivism (Broadbent & Mareschal, 2019; Westermann et al., 2007). The next sections give a brief outline of adult's skills, a skill model adapted to the current study, the relevance of social comparison theory, and the neuroconstructivist perspective on skills before presenting the current study.

Frameworks of Adults' Skills

Adults' skills are domain specific (Karmiloff-Smith, 2012; Şenol, 2022; Westermann et al., 2007), highly important for their life-long education, health, occupational career, and constructive participation in a globalized society (Čopková et al., 2021; European Commission, 2021, 2023; Kitanova, 2020; OECD, 2021). One of many existing frameworks used for international large-scale assessments describes core domain skills and transversal skills (see OECD, 2021 for an overview). Core domain skills are mathematic literacy (i.e., an individual's capacity to formulate, apply and interpret mathematical tasks in different contexts), reading literacy (i.e., an individual's capacity to use text material to gain

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knowledge, reach a goal, or participate in the society), and science literacy (i.e., an individual's capacity to explain, evaluate, and interpret phenomena scientifically, OECD, 2017, 2021).

Transversal skills are problem solving (i.e., an individual's capacity and engagement to cognitive processing, understanding and resolving subjectively new problems), collaboration (i.e., to engage in a process to resolve a problem together with one or more agents), creative thinking (i.e., to generate, evaluate and improve ideas to advance knowledge and effective expressions of imagination, OECD, 2021), learning in a digital world (i.e., the acquisition of novel information using at least one digital device and corresponding change in behavior, knowledge, or brain function, (American Psychological Association [APA], n.d.), and global competence (i.e., an interplay of an individual's skills, values, and attitudes that facilitates locally and cross-culturally socially appropriate behavior, OECD, 2021). Core skills and transversal skills are necessary for education in school, and due to specialization in part for vocational education, higher education, occupation, and lifelong learning. Furthermore, tested core skills and tested transversal skills seem to be positively interrelated to each other (Kyllonen, 2021).

Problem solving, for example, is a complex skill set (Wirth & Klieme, 2003) involving cognitive and metacognitive processes (Goldhammer et al., 2014; Greiff et al., 2013) rather than an a priori domain-specific skill. Indeed, when domain-specific tasks or demands encompass a nonroutine problem (Mayer, 1998), the individual will ideally transfer his/her problem-solving skills to these tasks or demands. Accordingly, individuals often use problem-solving in mathematical tasks (e.g., the rule of three) and social contexts (e.g., in conflict-filled social situations). The current study focused on operational definitions of adults' numeracy, literacy, and social skills for the survey of adult skills (PIAAC) with regard to its longitudinal extension (PIAAC-L) in Germany outlined next.

Framework in the Survey of Adults' Skills

PIAAC is an international comparative trend study and large-scale initiative (OECD, 2013, 2015, 2016). One aim of PIAAC is to assess key skills considered to be personally important for individuals' life chances and desirable for adults in society (Zabal et al., 2014, 2016), such as numeracy and literacy skills (see Rammstedt et al., 2017, for a brief outline of the study's design).The nationally representative 2012 PIAAC has been extended to the longitudinal study PIAAC-L in Germany (Rammstedt et al., 2017). The main idea of this extension was to examine the relations between life circumstances (e.g., activities at work, leisure activities) and key adult skills over the lifespan (for a full description, see https://www.gesis.org/en/en/piaac/piaac-home/).

Numeracy is operationally defined as "the ability to access, use, interpret, and communicate mathematical information and ideas, in order to engage in and manage the mathematical demands of a range of situations in adult life" (PIAAC Numeracy Expert Group, 2009, p. 21). According to the conceptual framework of the Adult Literacy and Life Skills Survey (ALL Framework), numeracy involves cognitive processes such as identifying, locating or accessing, acting upon or using, interpreting, evaluating, analyzing, and communicating (Zabal et al., 2014). One example of assessments is the number series task battery (Engelhardt & Goldhammer, 2018).

Literacy is operationally defined as "understanding, evaluating, using and engaging with written texts to participate in society, to achieve one's goals, and to develop one's knowledge and potential." (PIAAC Literacy Expert Group, 2009, p. 8). The literacy framework for PIAAC (Sabatini & Bruce, 2009; Zabal et al., 2014) encompasses not only prose or documents but also texts in digital environments. Relevant cognitive processes are accessing and identifying, integrating and interpreting, evaluating and reflecting (Zabal et al., 2014).

Social skills. In PIAAC, adults' use of social skills is conceptualized within the job requirements approach (JRA, skill use; Felstead et al., 2007; Santiago-Vela & Hall, 2022). The job requirements approach encompasses a set of self-report items developed for the PIAAC background questionnaire based on previous studies (Felstead et al., 2007). Respondents answered questions about their cooperative activities, sharing work-related information, giving talks to others, and advising or negotiating with others both at work and outside work (OECD, 2013; Rammstedt et al., 2017). Thus, adults' frequent use of social skills is related to the number of opportunities they have to interact with their social environment (henceforth 'adults' social lives'). The number of these opportunities in adults' private lives depends in part on household size or the number of close friends. Consequently, adults' frequent use of social skills might be related to their later social lives (e.g., household size or the number of close friends).

Social Comparison Theory and Neuroconstructive Perspective

Adult's skill use is usually related to their self-evaluations of these skills (see Zell & Krizan, 2014, for a metasynthesis). Festinger (1954, p. 118) proposed that an individual's self-evaluations are fragile when too few "social means" or "objective means" (i.e., external frames of reference) are available. The need to engage in social interactions with clients, patients, students, customers or others is often linked to limited time with colleagues and high average weekly working hours. The limited time with colleagues (e.g., teachers at school) restricts the "social means" and "objective means" (Festinger, 1954, p. 118) available for comparisons with colleagues at work (Goethals, 1986; Paulick et al., 2017). In such cases, Festinger (1954, p. 118, Hypothesis II) assumed "to the extent, that objective, non-social means are not available, people evaluate their opinions and abilities by comparison respectively with the opinions and abilities of others." This

hypothesis implies that frequently used skills might be self-evaluated based on (a) objective frames of reference, such as the results of performance tests, and if these are not available, (b) social frames of reference such as others' perceived skills.

Moreover, adults who feel lonely (Mund et al., 2020; Sherman et al., 2000; Solano, 1986) and have fewer opportunities to use objective frames of reference (e.g., the results of performance tests) or social frames of reference (e.g., social interactions with colleagues) probably experience uncertainty (Festinger, 1954) when they self-evaluate their frequently used skills. This uncertainty might not only concern the self-evaluation of numeracy or literacy, but also adults frequently used social skills in relation to their later social lives.

Later findings from studies with school students (Marsh, 1987; Marsh et al., 2015; see Möller et al., 2009, 2020, for a meta-analytic path analysis) and adults (Crusius et al., 2022; Freund & Kasten, 2012; Mussweiler, 2003; Paulick et al., 2017) support Festinger's social comparison theory.

Evidence exists with regard to the accuracy of adults skill self-evaluations, for example, in comparison with performance test scores (Kluemper et al., 2019; Rohrmann et al., 2016; Zell et al., 2020; Zell & Krizan, 2014; Zell & Lesick, 2022). However, there is scant evidence on the relationship between adults frequently used skills, corresponding self-evaluations and their social lives over time although these skills and adults' social environments are highly important for our society in present and future (OECD, 2021).

The assumed existence of relationships between frequently used skills and corresponding self-evaluations over time is supported by research on neuroconstructivism. From a neuroconstructive perspective, the domain specificity of skills results in part from activities since early childhood involving interactions between an individuals' environment and biological traits (Karmiloff-Smith, 2012; Westermann et al., 2007). The domain-specification of individuals' skills emerges from interactions with their environment (e.g., frequent huge numbers of count stimuli over time and the initial count processing constraints, Karmiloff-Smith, 2012). Research findings from neuroimaging studies (Karmiloff-Smith, 2012; Király, 2022; Westermann et al., 2007) support the neuroconstructive perspective on the domain specificity of individuals' skills regressed in part on the opportunities to use it as often as possible in their daily lives. Thus, frequently used domain-specific skills of adults might be positively related over time to skills or related factors in that domain.

Further Relevant Factors

Previous research has indicated that individual differences in self-evaluated skills can be explained in part by age, cognitive abilities, and ethnic and socioeconomic background (Schneider, 2018; see Zell & Krizan, 2014, for a metasynthesis). For example, an inverted U-curve was found regarding adults' self-evaluated cognitive skills across the lifespan (Konrath et al., 2011) in a meta-analysis of transversal studies suggesting age effects in self-evaluations.

An adult's history of immigration (ethnic background) is linked to language (Maehler et al., 2017), communication, social culture (Oyserman, 2017), gender role models and labor market outcomes (Braun, 2018). Indeed, language and social cultures can impair the use and self-evaluation of numeracy, literacy, and social skills. Participants' actual weekly working hours including any overtime were further considered in the analyses due to evidence that 55 weekly hours or more compared to 35–40 hours (Virtanen et al., 2009) related to declines in cognitive functions (Sharma et al., 2022; Virtanen et al., 2009), onset of depressive symptoms (Virtanen et al., 2018), and longer working lives to career destabilization (Riekhoff, 2018). These further relevant factors (e.g., tested skills, ethnic backgrounds, actual weekly working hours) should be considered when analyzing adults' self-evaluated skills and their social lives.

In the current study, relations are assumed between adults' frequent use of numeracy, literacy, or social skills and self-evaluated numeracy or literacy as well as variables related to adults' social lives over time. Scientific use files from PIAAC provide data to examine the assumed relations.

Present Research

This research aimed to analyze whether frequent use of numeracy, literacy, and social skills is related to self-evaluated numeracy and literacy skills, and to variables related to individuals' social lives over time. The research question was: Is adults' frequent use of numeracy, literacy, and social skills related to their self-evaluated numeracy, literacy and variables concerning their social lives over time?

The hypotheses were as follows: (a) H_1: There is a positive relationship between adults' frequent use of numeracy skills and their self-evaluation of numeracy skills three years later, controlling for the covariates gender, age, numeracy, and literacy test scores, birth origin (Maehler et al., 2017; Oyserman, 2017; Schneider, 2018; Zell & Krizan, 2014), weekly working hours (Sharma et al., 2022; Virtanen et al., 2009), and socioeconomic background (Schneider, 2018; see Zell & Krizan, 2014). (b) H_2: There is a positive relationship between adults' frequent use of literacy and their self-evaluated literacy three years later, considering the same covariates as in (a). (c) H_3: There is a positive relationship between adults' frequent use of social skills and their self-evaluated numeracy and literacy three years later, considering the same covariates as in (a). (d) H_4: Frequent use of numeracy and literacy is negatively related but frequent use of social skills is positively related to individuals' social lives three years later (operationalized as household size and number of close

friends), considering the same covariates as in (a). Figure 1 presents a theoretical model constructed according to these hypotheses and considering relationships between frequent use of skills, self-evaluated skills and variables concerning participants' social lives.

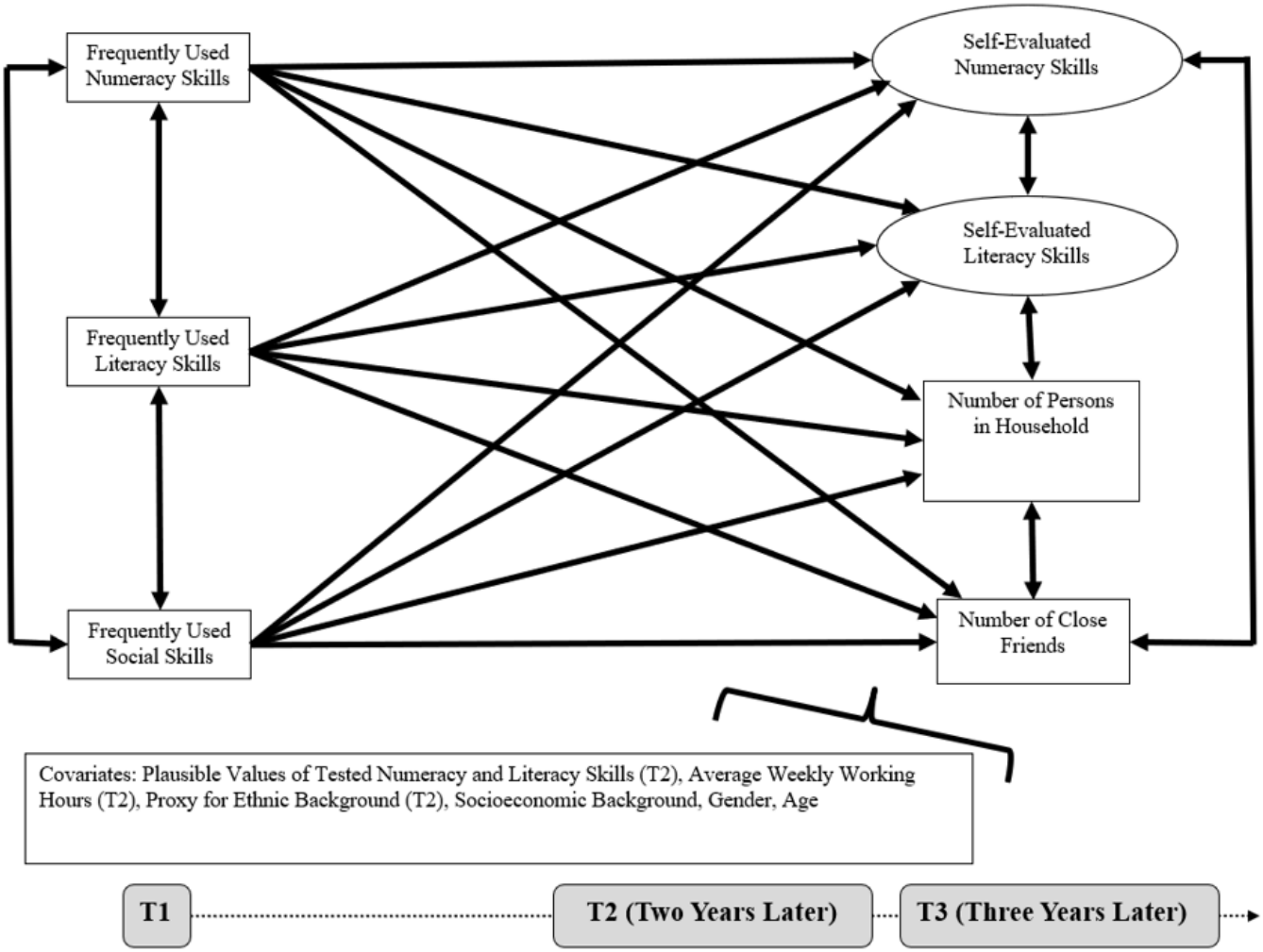


Figure 1. Hypothetical Model

Methodology

Sample

Data were taken from the scientific use files of the PIAAC survey in 2012 (Zabal et al., 2014) and PIAAC-L surveys in 2014, 2015, and 2016 (Rammstedt et al., 2017, available at https://search.gesis.org/research_data/ZA5989). The sample for longitudinal analyses consisted of N = 3263 adult anchor persons in Germany who were interviewed in 2012 and again in 2014, 2015, and 2016 (49% male, M_{age} = 40.28, SD_{age} = 13.87, Min_{age} = 16 years, Max_{age} = 65 years). Socioeconomic background data were available for n = 2461 participants (802 missing values on the ISEaI variable at T3), with ISEI scores ranging from 11.56 to 88.96, with the median M_{med} = 48.10. Six percent (n = 192) of 3263 persons indicated that they were born outside Germany as a proxy for ethnicity (Maehler et al., 2017; Oyserman, 2017; Schneider, 2018; Zell & Krizan, 2014). The PIAAC and PIAAC-L studies obtained institutional research ethics committee approval and participants' consent. Interviewers collected the data using standardized questionnaires and cognitive performance tests (Rammstedt et al., 2017; Zabal et al., 2017). Leibniz Institute for the Social Sciences (GESIS) provides longitudinal data for scientific use purposes. The baseline of PIAAC-L was Time 1 (T1, 2012), followed by Times 2–3 (T2, 2014; T3, 2015), which were used in the current study.

Measures

The interviewers presented the following items in German. The items have been translated into English for the present paper. More details about the complete list of measures and interview procedure can be found in Zabal et al. (2017).

Predictor variables. Twelve self-report items assessed participants' frequency of numeracy use at work and in their daily life, for example: (a) At your current job, how often do you normally use fractions, decimals or percentage information? or (b) At your current job, how often do you normally use higher mathematics or statistics for analysis, complex algebra, trigonometry or regression analyses? Participants indicated on a 5-point scale ranging from 1 (*never*) to 5 (*daily*) how often they used numeracy at work or in their private life (McDonalds ω = .83). Internal consistency was acceptable according to suggested interpretations from other researchers (Dunn et al., 2014; Schweizer, 2011). In the statistical model, the sum score (T1) was included as a covariate for the criterion variables (T3) self-evaluated numeracy and literacy, household size and close friends, as detailed below.

Twelve self-report items assessed participants' frequency of literacy use at work and in their daily life, for example: (a) At your current job, how often do you normally read articles in scientific journals or scientific publications? or (b) At your current job, how often do you normally write reports? Participants indicated on a 5-point scale ranging from 1 (*never*) to 5 (*daily*) how often they used literacy at work or in their daily life. Internal consistency was acceptable (McDonalds ω = .76). In the statistical model, the sum score (T1) was included as a manifest covariate for the criterion variables (T3).

Eleven self-report items assessed participants' frequency of use of social skills at work and in their daily life, for example: (a) At your current job, how often do you normally negotiate with persons inside or outside your company or factory? or (b) At your current job, how often do you teach persons one-to-one or in groups? Participants indicated on a 5-point scale ranging from 1 (*never*) to 5 (*daily*) how often they were involved in social interactions at work or in daily life. Internal consistency was acceptable (McDonalds ω = .77). In the statistical model, the sum score (T1) was included as a manifest covariate for the criterion variables (T3).

Criterion variables. Eight items on self-evaluated numeracy and eight items on self-evaluated literacy measured participants' self-evaluated numeracy or literacy, respectively. The items were introduced with: The next question requires you to assess your numeracy/literacy skills. I am reading aloud different numeracy/literacy skills. Please tell me how well you can perform each of these skills. Think about your experiences at work and at home. Please answer using this list. Examples from the numeracy list are: calculate percentages; analyze or interpret statistical data. Examples from the literacy list are: read and understand official documents; understand arguments for/against something in text. Participants indicated on a 5-point rating scale ranging from 1 *(I am not at all able to do this*) to 5 (*I am able to do this very well*) whether they believed they would be able to complete the tasks described in the items (McDonald's ω = .92 for self-evaluated numeracy and ω = .92 for self-evaluated literacy).

The adult responded directly on the question how many persons live in her/his household (including themselves, and including all children living in the household. This question assessed the absolute number of persons in household or household size (Martin et al., 2022). Furthermore, the following question assessed the absolute number of close friends: What would you say: How many close friendships do you have? (Martin et al., 2022). Both self-evaluation scales, household size, and number of close friends at Time 3 were included as criterion variables in the statistical model. Due to the correlational design and based on previous studies (Goldhammer et al., 2017; Gorges et al., 2016; Rammstedt et al., 2017; Zabal et al., 2017), some background variables need to be taken into account as covariates.

Covariates. As already mentioned above, further relevant factors should be considered when analyzing adults' self-evaluated skills and their social lives. Previous research has suggested relations between tested skills and self-evaluated skills (e.g., Zell & Krizan, 2014). Accordingly, these relations were considered in the current study by including the *tested numeracy* and *tested literacy* (T2) in the statistical model. Numeracy and literacy were tested with a randomized block design and plausible values were estimated (Khorramdel et al., 2020; Rammstedt et al., 2017). The participants did not receive their test results. These plausible values are provided in the PIAAC-L scientific use files (see https://www.gesis.org/en/en/piaac/piaac-home/).

The background variables used were included in the PIAAC background model (Khorramdel et al., 2020; Perry et al., 2018; Zabal et al., 2017), these are gender, age, and ethnicity (Maehler et al., 2017; Oyserman, 2017; Schneider, 2018; Zell & Krizan, 2014). Males were coded as 0 and females were coded as 1. Being born in Germany was coded as 0, being born outside Germany as 1 as a proxy for adult's ethnicity due to its above introduced evident relevance (Maehler et al., 2017; Oyserman, 2017; Zell & Krizan, 2014). Socioeconomic background (ISEI) was used due to its above mentioned evident relevance for adults' self- evaluations in previous research (Schneider, 2018; see Zell & Krizan, 2014, for a metasynthesis).

Based on previous findings on the relationship between self-reported number of working hours and adults' social lives (Cinamon, 2016), adults' self-reported average weekly working hours were included in the current study. The interviewer asked the participant: *How many hours do you actually work per week on average, including any overtime?* Average weekly working hours assessed at T2 served as a covariate for the criterion variables (T3) in the Bayesian structural equation model (BSEM). These further relevant factors were included in the present study as other researchers suggested (Pekrun et al., 2017).

Missing values. Missing values for the criterion variables (i.e., self-evaluated numeracy and literacy, household size, number of close friends at T3) ranged from 0% to 1%. The proportion of missing values for frequency of social,

numeracy, and literacy skills use at T1 was above 5%, as was the proportion of missing values for participants' actually weekly working hours. Supplemental Table 1 shows the number of missing values (see Appendix).

Statistical Analyses

First, the four criterion variables, namely self-evaluated *numeracy* and *literacy*, number of *close friends* and *household size* at T3, which represent the factors of current interest based on the aforementioned theory and hypotheses, were included in a Bayesian confirmatory analysis (BCFA). Second, the covariates were added to specify the BSEM, namely frequent use of numeracy, literacy and social skills at T1. Supplemental Figure 1 presents the technical model (see Appendix).

Note that variables available as part of the background model for plausible values provided in the scientific use files were included as covariates in the current statistical analyses (Khorramdel et al., 2020). Plausible values are necessary due to the block-randomized design applied in PIAAC (Braun & von Davier, 2017; Zabal et al., 2014). The variables gender, age, ethnicity, tested numeracy and literacy (including plausible values), weekly working hours at T2 and ISEI served as covariates in the BSEM. Data analyses were conducted in the software environment R (R Core Team, 2013) using the packages *psych* (Revelle, 2017) to analyze reliability and *blavaan* for the BSEM (Merkle et al., 2019). All variables used in this study were grand mean centered and scaled before the analyses (R Core Team, 2013). BCFA and BSEM (Merkle et al., 2019) are analyses based on Bayes' theorem (Stigler, 2013). The specifications of prior and posterior distributions are detailed next.

Bayesian analyses: Prior specification. The Bayesian approach was used to quantify the uncertainty of results and update this uncertainty by including prior knowledge than it would be possible using the frequentist approach (Kaplan, 2016). In brief, the Bayesian paradigm involves a criterion variable epsilon (ε, e.g., a self-evaluation score) and a parameter theta (θ) that might characterize the target probability model. Statistical inference is then required to obtain information about the unknown parameter θ, which is a fixed value in frequentist approaches. Bayesian statistical inference is based on the assumption that θ is a random variable within a certain probability distribution. This probability distribution represents the uncertainty about whether θ is close to the true value. Both the criterion variable ε and the unknown parameter θ are assumed to be random variables, such that they can be included in a joint probability model with the data and the prior parameter distribution (see Kaplan, 2016; Kaplan & Lee, 2018, for formal descriptions, or van de Schoot et al., 2014, for a gentle introduction).

The uncertainty regarding the effect of frequent use of certain skills on self-evaluations about these skills expressed by the prior distribution of θ is weighted using the observed data, resulting in an updated uncertainty estimate expressed in the posterior density of parameter θ (Kaplan, 2016) given the observed self-evaluation outcome. Thus, weighting and estimation of the posterior density depend on the prior probability distribution. This dependency highlights how important it is to specify an appropriate prior probability distribution (Kaplan, 2016).

Researchers have been estimating the accuracy of ability self-evaluations for more than three decades. There have been meta-analyses focused on correlational effects and their distributions over studies with regard to intelligence (Freund & Kasten, 2012) and interpersonal sensitivity (Hall et al., 2009). In primary research (Holling & Preckel, 2005), authors have reported means and standard deviations of self-evaluations that, however, based on different assessments and different response levels than the self-evaluation assessments included in PIAAC-L. In PIAAC-L, no previous self-evaluation data are available that would be appropriate prior distributions to include in BSEM. Finally, the specified BSEM included general normal prior distributions implemented in the package *blavaan* (Merkle et al., 2019; Merkle & Rosseel, 2018) to call the Stan Software packages for Bayesian statistics (Merkle et al., 2021; Stan Development Team, 2017). Stan allows, for example, to specify log density functions in Stan's probabilistic programming language for full Bayesian statistical inference with MCMC sampling (Stan Development Team, 2017). The BSEM in this study involved three MCMC chains with 2000 iterations. Trace plots (after doubling the iterations), density plots, autocorrelation plots, and the potential scale reduction factors (Brooks & Gelman, 1998; Gelman & Rubin, 1992; Merkle et al., 2019, 2021; Merkle & Wang, 2018) were used to judge, if the MCMC chains converged. In case of convergence, the ratio of the between-chain variance to the within-chain variance yields a potential scale reduction factor close to 1 (Merkle & Wang, 2018).

Results

In the current sample (n = 3263) for longitudinal analyses, n = 66 adults indicated that they never use numeracy and n = 44 used aspects of numeracy every day. Eight adults indicated that they never use literacy and n = 33 adults used aspects of literacy every day. With regard to social skills, n = 13 adults indicated that they never use social skills and n = 230 adults used some social skills every day. Supplemental Table 1 presents means and standard deviations (see Appendix)

The posterior summary statistics and highest posterior density (HPD) of 98 parameters suggested acceptable model fit between the model and the data (Garnier-Villarreal & Jorgensen, 2020; Hoofs et al., 2018): chi-square based posterior predictive p-value (PPP_{X2}) < .001, deviance information criterion (DIC) = 73416.617, p_{DIC} = 98.336; Bayesian variant of the root mean square error of approximation (BRMSEA) = .069, 90% credible interval (CI) [.069, .070]; $\widehat{BI}$ = .910, 90% CI [.908, .910]. Figure 2 presents the key trace plots, Figure 3 the trace plots after doubling the iterations, Figure 4 the

degree of autocorrelations between the iterations, Figure 5 parameter estimates of all chains in posterior distribution histograms, and Figure 6 the corresponding density plots. Table 1 gives an overview of the results with regard to the hypotheses, $\hat{R}$ of the Gelman-Rubin convergence diagnostics (Gelman & Rubin, 1992), and results of the sensitivity analysis (Depaoli & van de Schoot, 2017).

The trace plots in Figure 3 suggested chain convergence, also after doubling the iterations (Depaoli & van de Schoot, 2017). The degree of autocorrelations between the criterion variables (i.e., self-evaluated numeracy and literacy, number of persons in household and close friends) with frequently used numeracy, literacy, and social skills were also acceptable (see Figure 4). The Gelman-Rubin diagnostic for assessing chain convergence by the within and between chain variability yielded potential scale reduction factors (PSRF; Gelman and Rubin 1992) close to 1 with $\hat{R}$ = 1.000–1.002 (see Table 1), suggesting chain convergence (Merkle et al., 2021).

Posterior Distributions and Sensitivity Test Results

The histograms in Figure 5 present estimated posterior distributions of regression coefficients representing the three frequently used skills at T1 related to adults' self-evaluations three years later at T3. The distributions are clearly unimodal around one value each and suggest, adding more iterations would rarely yield more information (Depaoli & van de Schoot, 2017).

The sensitivity analysis of the general normal (default in *blavaan*, Merkle et al., 2019) prior distribution's possible influence on the model parameter vs a theoretically plausible prior distribution yielded small deviances (0.01–0.09) between the measured factors' posterior estimates from the target BSEM and the BSEM with doubled iterations.

Table 1 presents the effects (i.e., posterior point estimate similarly interpretable as a beta weight in frequentist statistics), posterior standard deviations, and highest posterior densities (i.e., credible intervals known as confidence intervals in frequentist statistics) from the BSEM described in the Statistical Analyses section. With regard to the four hypotheses, the posterior distributions suggested that, as expected in Hypothesis (a), adults' frequent use of numeracy was positively related (posterior credible effect A = 0.215, CI [0.152, 0276]) to self-evaluated numeracy three years later when taking into account the covariates gender, age, numeracy and literacy performance, born inside or outside Germany as a proxy for ethnicity, average weekly working hours, and socioeconomic background (see Table 1). Furthermore, (b) frequent use of literacy at T1 was positively related (posterior credible effect A = 0.224, CI [0.155, 0295], see Table 1) to self-evaluated literacy three years later at T3, again considering the covariates mentioned in (a). (c) Table 1 also presents that the frequent use of social skills at T1 was positively related to self-evaluated numeracy and literacy three years later at T3, again considering the covariates mentioned in (a). (d) Frequent use of social skills at T1 was positively related to *household size,* capturing individuals' social lives three years later at T3. Participants who often used literacy had a higher probability of reporting a higher number of close friends three years later than those who did not often use literacy. Frequent use of numeracy and social skills at T1 did not relate to the number of close friends three years later at T3. Frequent use of numeracy or literacy did not relate to *household size*. Note that the covariates (i.e., gender, age, numeracy and literacy performance, the proxy for ethnicity, average weekly working hours, socioeconomic background) were included in this model because they affected individuals' self-evaluations in previous studies (Konrath et al., 2011; Maehler et al., 2017; Schneider, 2018; Zell & Krizan, 2014). Thus, a closer look at the effects of the covariates on the criterion variables is valuable. Indeed, numeracy test scores (plausible values at T2) were positively related to self-evaluated numeracy but not to self-evaluated literacy at T3 (see Table 1); in turn, literacy test scores at T2 were positively related to self-evaluated literacy but not to self-evaluated numeracy at T3.

Positive relationships existed between the adults' socioeconomic status, age, and self-evaluated numeracy. Males scored higher in self-evaluated numeracy than females; in turn, females scored higher in self-evaluated literacy than males. A high socioeconomic status also predicted highly self-evaluated literacy. However, adults of higher age self-evaluated their literacy relatively low. The participants included in the current study indicated working 37 hours per week on average at T2 (M = 37.27, SD = 13.38; Min = 1 hr, Max = 79 hrs, M_{median} = 40 hrs), which was not related to their numeracy and literacy self-evaluations at T3. The proxy for ethnic background was also not related to their numeracy and literacy self-evaluations at T3.

A negative relationship existed between average weekly working hours, gender, age and household size one year later. Thus, more males than females and elderly people, who reported higher numbers of weekly working hours, lived alone or with a relatively small number of persons in a household. Adults born outside Germany as a proxy for ethnicity reported a larger household size than adults born in Germany. However, tested literacy (plausible values), ethnic background, and age were negatively related to the number of close friends.

High literacy scores were associated with less close friends than low literacy scores. People born out of Germany reported fewer close friends than people born in Germany. None of the further covariates were related to the variable *number of close friends.* The results are summarized and discussed in the next section.

Table 1. Effects, Posterior Standard Deviations, Highest Posterior Densities, and Potential Scale Reduction Factors From the Structural Equation Model of Adults' Self-Evaluated Skills and Social Lives

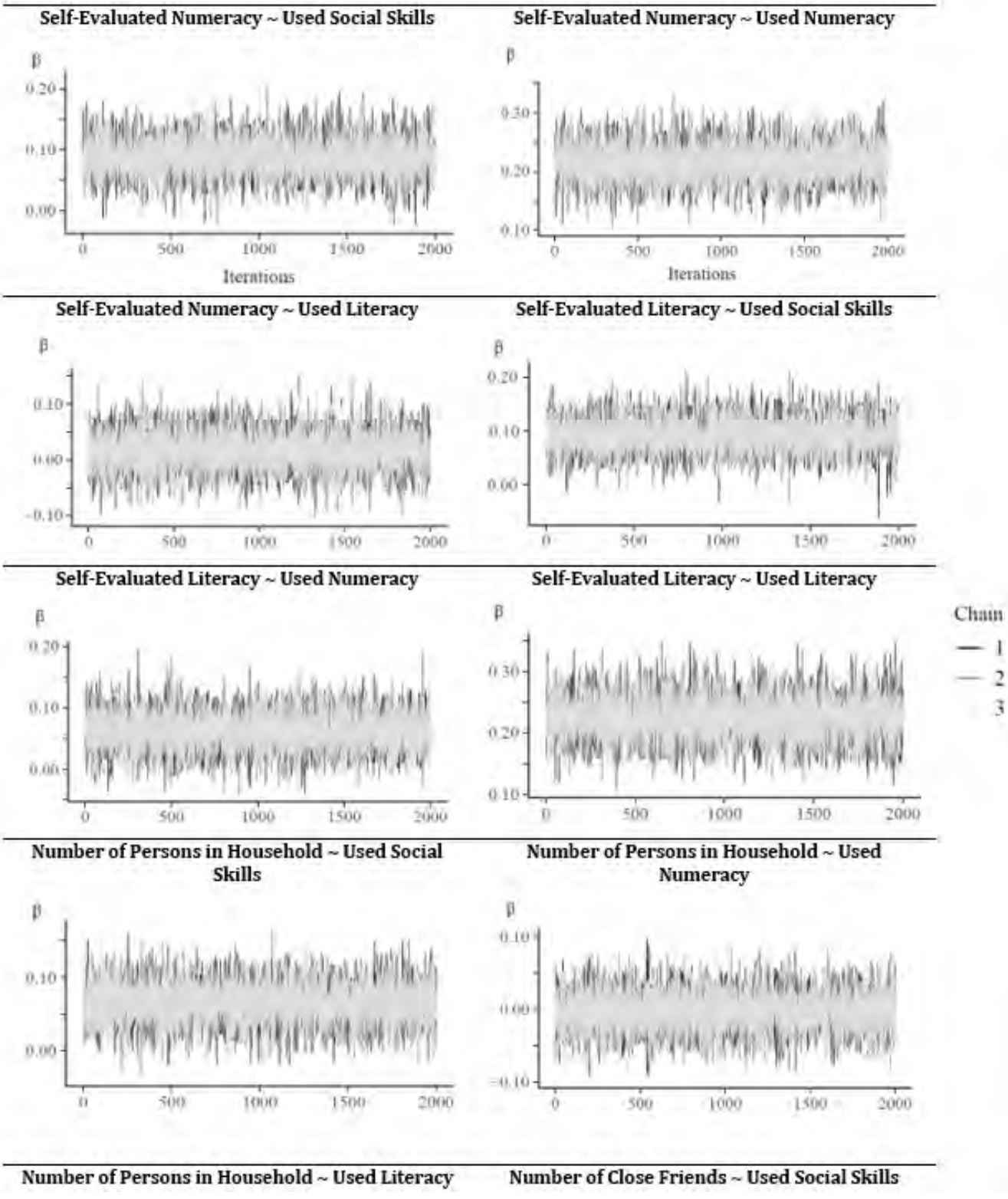
	Target Model						Sensitivity Analysis					
	Effect	**Posterior SD**	**95% HPD (.025)**	**95% HPD (.975)**	$\widehat{R}$	**Prior**	**Effect**	**Posterior SD**	**95% HPD (.025)**	**95% HPD (.975)**	$\widehat{R}$	**Prior**
Criterion Variable Self-Evaluated Numeracy, T3												
PV Used Social Skills, T1	**0.088**	0.032	0.024	0.153	1.000	0, 10	0.088	0.032	0.026	0.153	1.001	0, 10
PV Used Numeracy Skills, T1	**0.215**	0.032	0.152	0.276	1.000	0, 10	0.215	0.032	0.154	0.278	1.000	0, 10
PV Used Literacy Skills, T1	0.016	0.036	-0.053	0.081	1.000	0, 10	0.017	0.036	-0.053	0.087	1.000	0, 10
CV Numeracy†, T2	**0.461**	0.075	0.312	0.603	1.000	0, 10	0.461	0.075	0.317	0.606	0.999	0, 10
CV Literacy[1], T2	-0.070	0.074	-0.216	0.075	1.000	0, 10	-0.069	0.074	-0.213	0.074	1.000	0, 10
CV Working Hours, T2	0.009	0.031	-0.053	0.069	1.000	0, 10	0.100	0.032	0.037	0.162	1.000	0, 10
CV ISEI	**0.101**	0.032	0.039	0.162	1.000	0, 10	0.008	0.030	-0.051	0.067	1.000	0, 10
CV Ethnicity	0.031	0.026	-0.018	0.082	1.000	0, 10	0.031	0.025	-0.019	0.079	1.001	0, 10
CV Gender	**-0.200**	0.029	-0.255	-0.144	1.000	0, 10	-0.201	0.029	-0.258	-0.143	0.999	0, 10
CV Age	**0.100**	0.031	0.039	0.159	1.000	0, 10	0.100	0.031	0.041	0.162	1.000	0, 10
Criterion Variable Self-Evaluated Literacy, T3	~											
PV Used Social Skills, T1	**0.093**	0.032	0.030	0.155	1.000	0, 10	0.093	0.033	0.028	0.157	1.001	0, 10
PV Used Numeracy Skills, T1	**0.061**	0.031	0.001	0.123	1.000	0, 10	0.062	0.032	0.001	0.124	1.000	0, 10
PV Used Literacy Skills, T1	**0.224**	0.035	0.155	0.295	1.000	0, 10	0.224	0.036	0.154	0.295	1.000	0, 10
Numeracy[1], T2	0.113	0.075	-0.032	0.260	1.000	0, 10	0.113	0.079	-0.035	0.267	0.999	0, 10
Literacy[1], T2	**0.169**	0.075	0.022	0.317	1.000	0, 10	0.170	0.077	0.016	0.314	0.999	0, 10
Working Hours, T2	-0.007	0.030	-0.066	0.051	1.000	0, 10	0.142	0.032	0.080	0.204	0.999	0, 10
ISEI	**0.143**	0.032	0.079	0.205	1.000	0, 10	-0.007	0.030	-0.064	0.050	1.001	0, 10
Ethnicity	-0.020	0.026	-0.071	0.029	1.000	0, 10	-0.020	0.024	-0.068	0.028	1.000	0, 10
Gender	**0.059**	0.029	0.004	0.116	1.000	0, 10	0.060	0.028	0.005	0.114	1.000	0, 10
Age	**-0.071**	0.030	-0.129	-0.010	1.000	0, 10	-0.071	0.031	-0.132	-0.010	1.000	0, 10
Criterion variable number of persons in household, T3	~											
PV Used Social Skills, T1	**0.065**	0.028	0.008	0.119	1.000	0, 10	0.066	0.028	0.011	0.120	1.000	0, 10
PV Used Numeracy Skills, T1	-0.002	0.028	-0.055	0.053	1.000	0, 10	-0.003	0.028	-0.058	0.051	0.999	0, 10
PV Used Literacy Skills, T1	-0.035	0.032	-0.098	0.026	1.000	0, 10	-0.035	0.030	-0.093	0.027	1.000	0, 10
Numeracy[1], T2	0.080	0.066	-0.053	0.210	1.000	0, 10	0.080	0.067	-0.046	0.217	1.000	0, 10
Literacy[1], T2	-0.027	0.066	-0.160	0.100	1.000	0, 10	-0.026	0.067	-0.162	0.102	1.000	0, 10
Working Hours, T2	**-0.102**	0.026	-0.153	-0.051	1.000	0, 10	-0.011	0.028	-0.067	0.043	1.000	0, 10
ISEI	-0.011	0.028	-0.066	0.045	1.000	0, 10	-0.102	0.026	-0.154	-0.050	1.001	0, 10
Ethnicity	**0.083**	0.022	0.041	0.124	1.000	0, 10	0.083	0.023	0.038	0.128	1.000	0, 10
Gender	**-0.062**	0.026	-0.111	-0.011	1.000	0, 10	-0.063	0.025	-0.110	-0.015	0.999	0, 10
Age	**-0.132**	0.027	-0.187	-0.079	1.000	0, 10	-0.133	0.027	-0.185	-0.080	0.999	0, 10

† Plausible values (Khorramdel et al., 2020)

Table 1. Continued

	Target Model						Sensitivity Analysis					
	Effect	**Posterior SD**	**95% HPD (.025)**	**95% HPD (.975)**	$\hat{R}$	**Prior**	**Effect**	**Posterior SD**	**95% HPD (.025)**	**95% HPD (.975)**	$\hat{R}$	**Prior**
Criterion variable number of close friends	~											
PV Used Social Skills, T1	-0.042	0.029	-0.098	0.016	1.000	0, 10	-0.042	0.029	-0.099	0.015	0.999	0, 10
PV Used Numeracy Skills, T1	-0.025	0.028	-0.081	0.032	1.000	0, 10	-0.024	0.028	-0.080	0.031	1.001	0, 10
PV Used Literacy Skills, T1	**0.076**	0.032	0.014	0.138	1.000	0, 10	0.077	0.032	0.013	0.140	0.999	0, 10
Numeracy[1], T2	0.108	0.069	-0.022	0.244	1.000	0, 10	0.110	0.067	-0.017	0.243	0.999	0, 10
Literacy[1], T2	**-0.168**	0.068	-0.303	-0.036	1.000	0, 10	-0.170	0.066	-0.301	-0.040	0.999	0, 10
Working Hours, T2	0.001	0.026	-0.050	0.051	1.000	0, 10	0.054	0.030	-0.003	0.113	0.999	0, 10
ISEI	0.055	0.029	-0.001	0.111	1.000	0, 10	0.001	0.027	-0.053	0.054	1.000	0, 10
Ethnicity	**-0.069**	0.023	-0.114	-0.024	1.000	0, 10	-0.069	0.023	-0.113	-0.025	1.000	0, 10
Gender	-0.029	0.025	-0.077	0.020	1.000	0, 10	-0.028	0.026	-0.079	0.022	1.000	0, 10
Age	**-0.117**	0.028	-0.173	-0.063	1.000	0, 10	-0.118	0.028	-0.173	-0.061	0.999	0, 10
Variable	**Inter-cept**	**Posterior SD**	**95% HPD (.025)**	**95% HPD (.975)**	$\hat{R}$	**Prior**	**Interce pt**	**Posterior SD**	**95% HPD (.025)**	**95% HPD (.975)**	$\hat{R}$	**Prior**
Self-Eval. Numeracy Item 1	0.033	0.019	-0.004	0.071	1.001	0, 1	0.033	0.019	-0.005	0.072	1.001	0, 1
Self-Eval. Numeracy Item 2	0.015	0.020	-0.024	0.054	1.000	0, 1	0.015	0.020	-0.025	0.055	1.000	0, 1
Self-Eval. Numeracy Item 3	0.022	0.020	-0.017	0.062	1.001	0, 1	0.023	0.020	-0.016	0.061	1.001	0, 1
Self-Eval. Numeracy Item 4	0.012	0.021	-0.029	0.054	1.000	0, 1	0.012	0.021	-0.032	0.054	0.999	0, 1
Self-Eval. Numeracy Item 5	0.043	0.019	0.005	0.080	1.001	0, 1	0.044	0.019	0.006	0.082	1.000	0, 1
Self-Eval. Numeracy Item 6	0.007	0.020	-0.032	0.047	1.001	0, 1	0.007	0.020	-0.032	0.046	1.001	0, 1
Self-Eval. Numeracy Item 7	0.028	0.020	-0.011	0.067	1.001	0, 1	0.029	0.020	-0.011	0.067	1.001	0, 1
Self-Eval. Numeracy Item 8	0.025	0.020	-0.014	0.063	1.001	0, 1	0.025	0.019	-0.013	0.062	1.001	0, 1
Self-Eval. Literacy Item 1	0.053	0.019	0.017	0.091	1.000	0, 1	0.053	0.018	0.016	0.088	1.000	0, 1
Self-Eval. Literacy Item 2	0.039	0.020	< 0 .001	0.077	1.001	0, 1	0.039	0.019	0.002	0.076	1.000	0, 1
Self-Eval. Literacy Item 3	0.059	0.019	0.020	0.096	1.001	0, 1	0.059	0.019	0.021	0.096	1.000	0, 1
Self-Eval. Literacy Item 4	0.013	0.021	-0.028	0.056	1.000	0, 1	0.014	0.021	-0.027	0.055	0.999	0, 1
Self-Eval. Literacy Item 5	0.024	0.021	-0.016	0.064	1.000	0, 1	0.025	0.020	-0.014	0.065	1.000	0, 1
Self-Eval. Literacy Item 6	0.023	0.020	-0.017	0.062	1.002	0, 1	0.024	0.019	-0.014	0.061	1.000	0, 1
Self-Eval. Literacy Item 7	0.005	0.020	-0.035	0.045	1.002	0, 1	0.006	0.020	-0.033	0.045	1.000	0, 1
Self-Eval. Literacy Item 8	0.006	0.020	-0.034	0.046	1.001	0, 1	0.007	0.020	-0.031	0.046	1.000	0, 1
Number of Pers. in Household	0.004	0.022	-0.040	0.048	1.000	0, 1	0.003	0.022	-0.039	0.046	0.999	0, 1
Number of Close Friends	0.024	0.023	-0.020	0.069	1.000	0, 1	0.025	0.023	-0.021	0.071	0.999	0, 1

Note. PV = predictor variables, CV = covariate, ISEI = socioeconomic background, T1 = Time 1. HPD = highest posterior density, $\hat{R}$ = potential scale reduction factor. Prior (0, 10) = target model and sensitivity analysis included default prior *intercepts M* = 0, where the normal distribution was parametrized by *SD* = 10 (Merkle et al., 2021, see Merkle et al., 2019, for details). Prior (0, 1) = the normal prior distribution with *M* = 0 was also used for each *variable loading* in the target model and sensitivity analysis (Merkle et al., 2021, see Merkle et al., 2019, for details). Credible effects (= credibility intervals did not include zero) are depicted in bold.


Self-Evaluated Numeracy ~ Used Social Skills
Self-Evaluated Numeracy ~ Used Numeracy
Self-Evaluated Numeracy ~ Used Literacy
Self-Evaluated Literacy ~ Used Social Skills
Self-Evaluated Literacy ~ Used Numeracy
Self-Evaluated Literacy ~ Used Literacy
Number of Persons in Household ~ Used Social Skills
Number of Persons in Household ~ Used Numeracy
Number of Persons in Household ~ Used Literacy
Number of Close Friends ~ Used Social Skills
β
Iterations
Chain
1
2
3

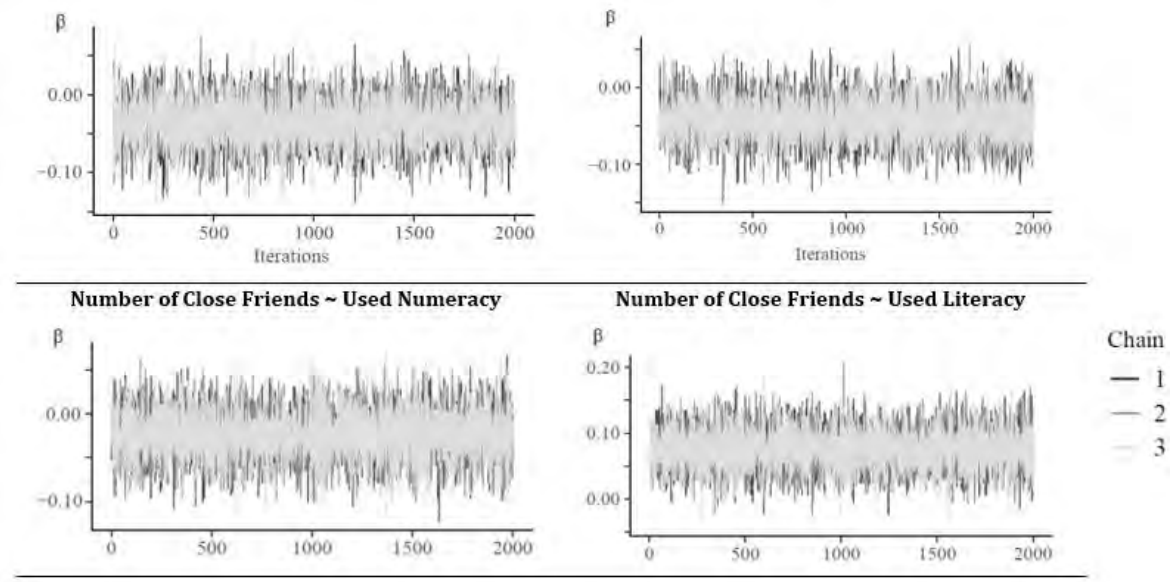
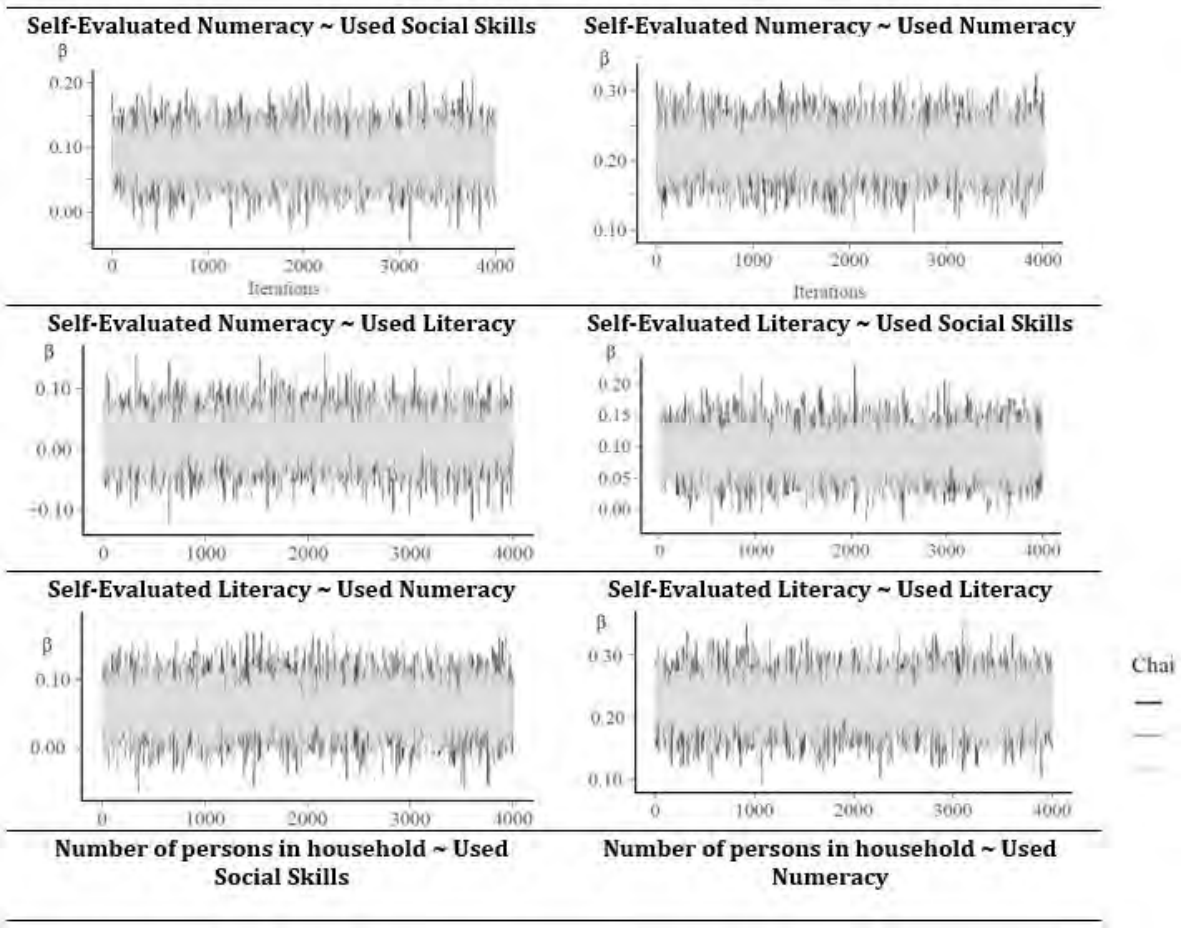


Figure 2. Trace Plots

Note. Criterion variables at T3: self-evaluated numeracy, self-evaluated literacy, number of persons in household, number of close friends; predictor variables at T1: frequently used social skills, frequently used numeracy, frequently used literacy.



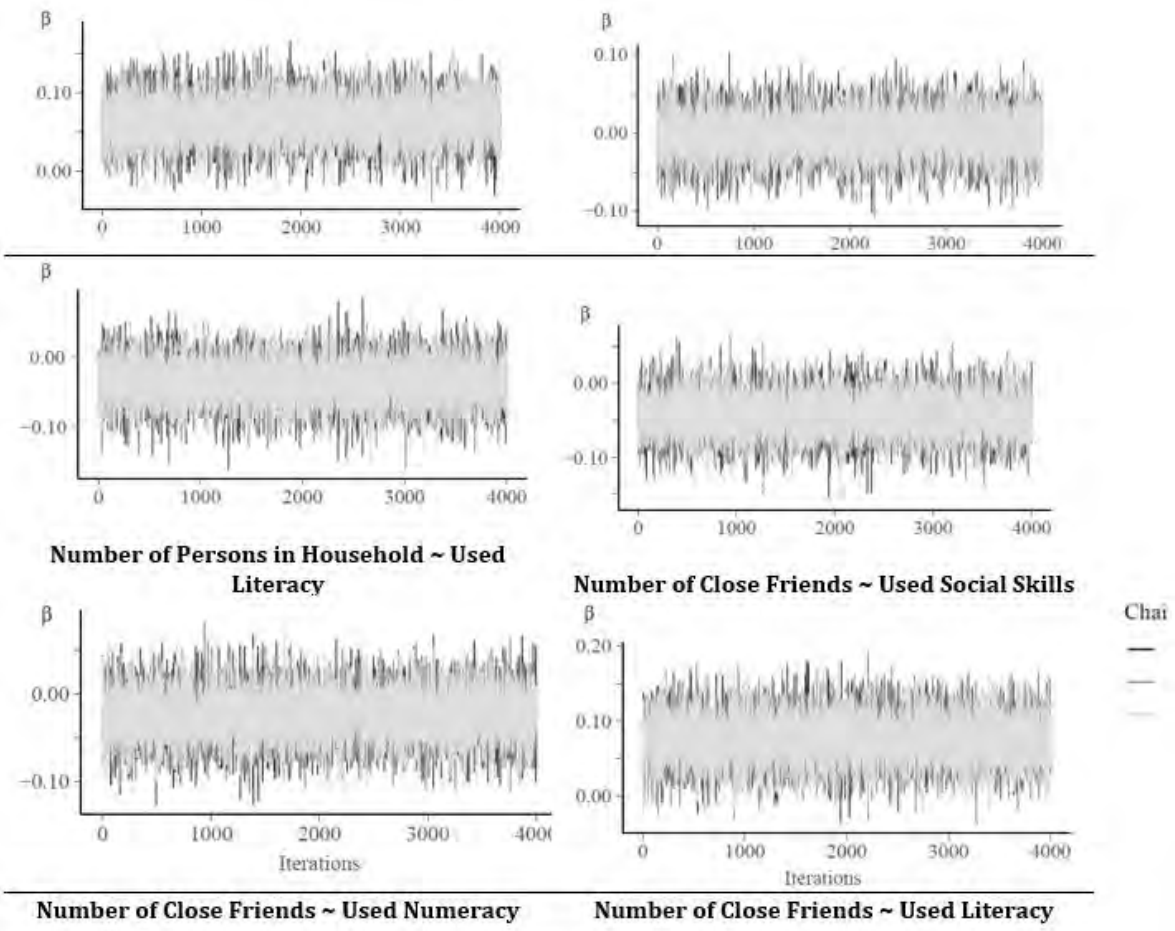
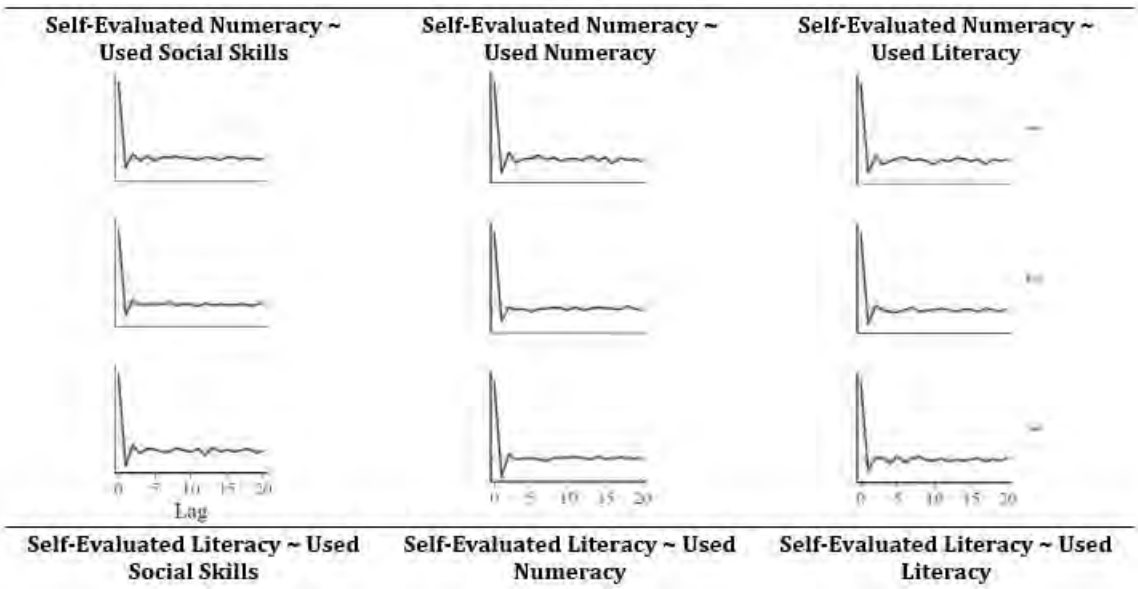


Figure 3. Trace Plots After Doubling the Iterations

Note. Criterion variables at T3: self-evaluated numeracy, self-evaluated literacy, number of persons in household, number of close friends; predictor variables at T1: frequently used social skills, frequently used numeracy, frequently used literacy.



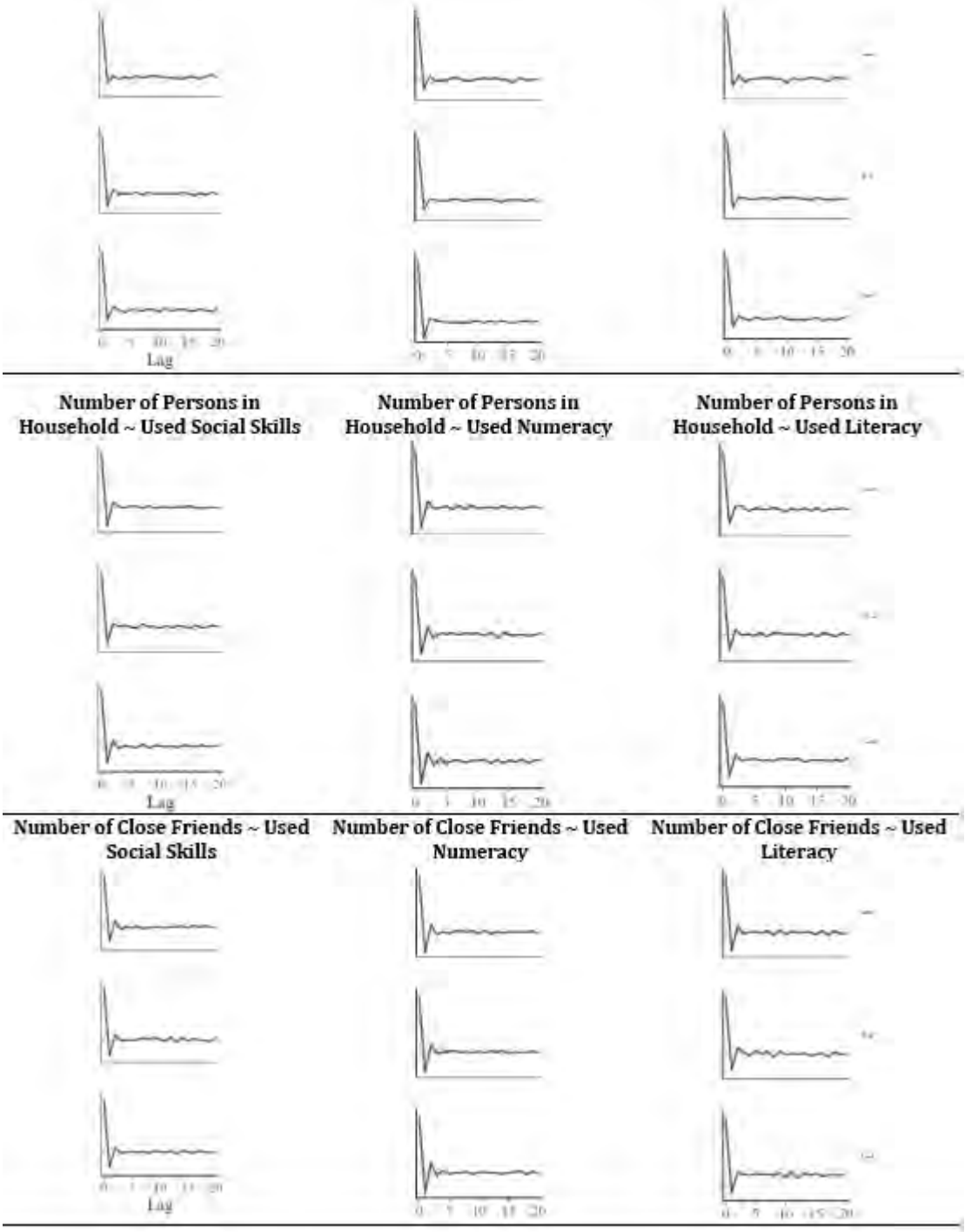


Figure 4. Degree of Autocorrelations Between the Parameter Estimates of all MCMC-Chains

Note. Criterion variables at T3: self-evaluated numeracy, self-evaluated literacy, number of persons in household, number of close friends; predictor variables at T1: frequently used social skills, frequently used numeracy; frequently used literacy.

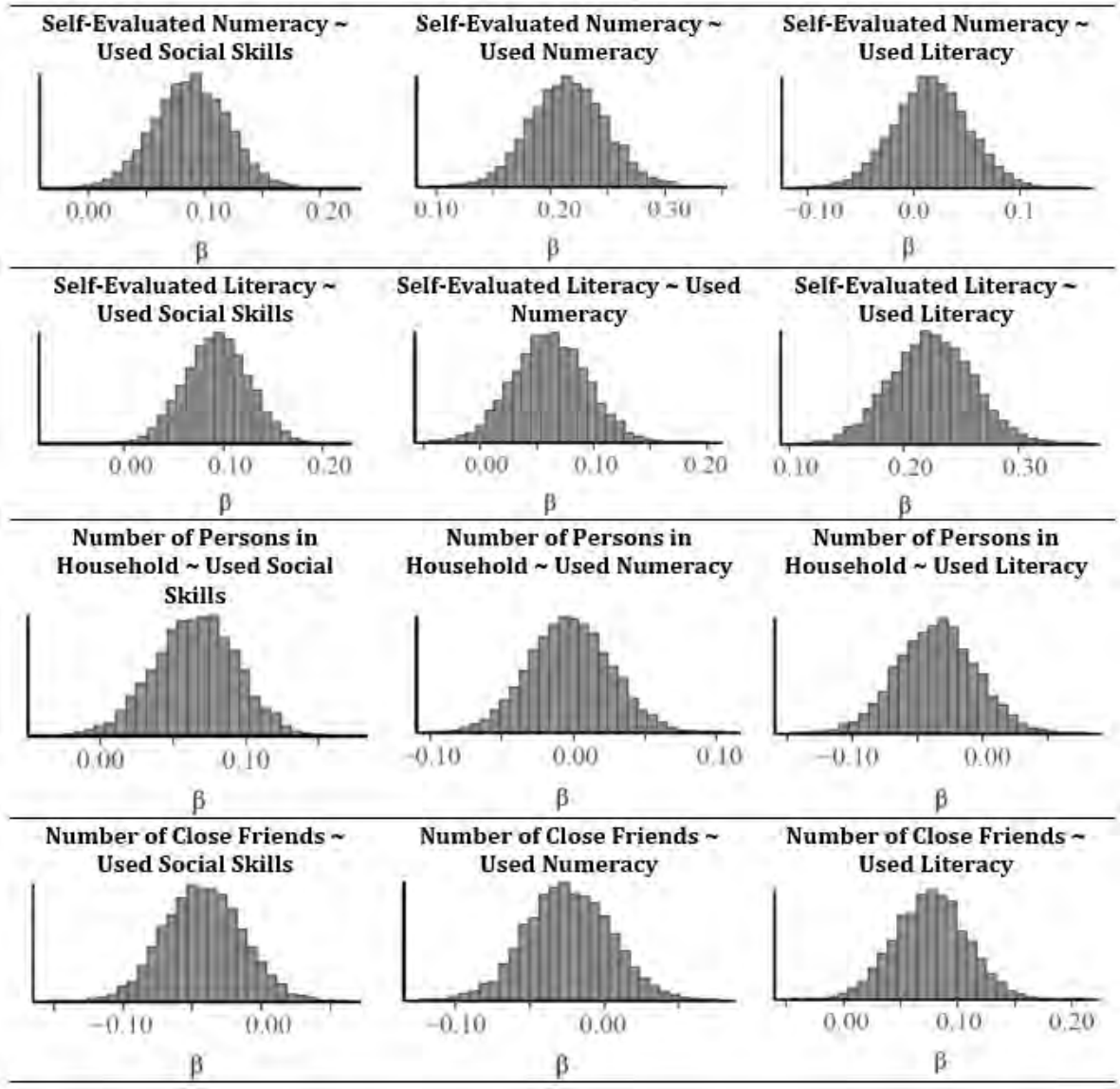


Figure 5. Parameter Estimates of all Chains in Posterior Distribution Histograms

Note. Criterion variables at T3: self-evaluated numeracy, self-evaluated literacy, number of persons in household, number of close friends; predictor variables at T1: frequently used social skills, frequently used numeracy; frequently used literacy.

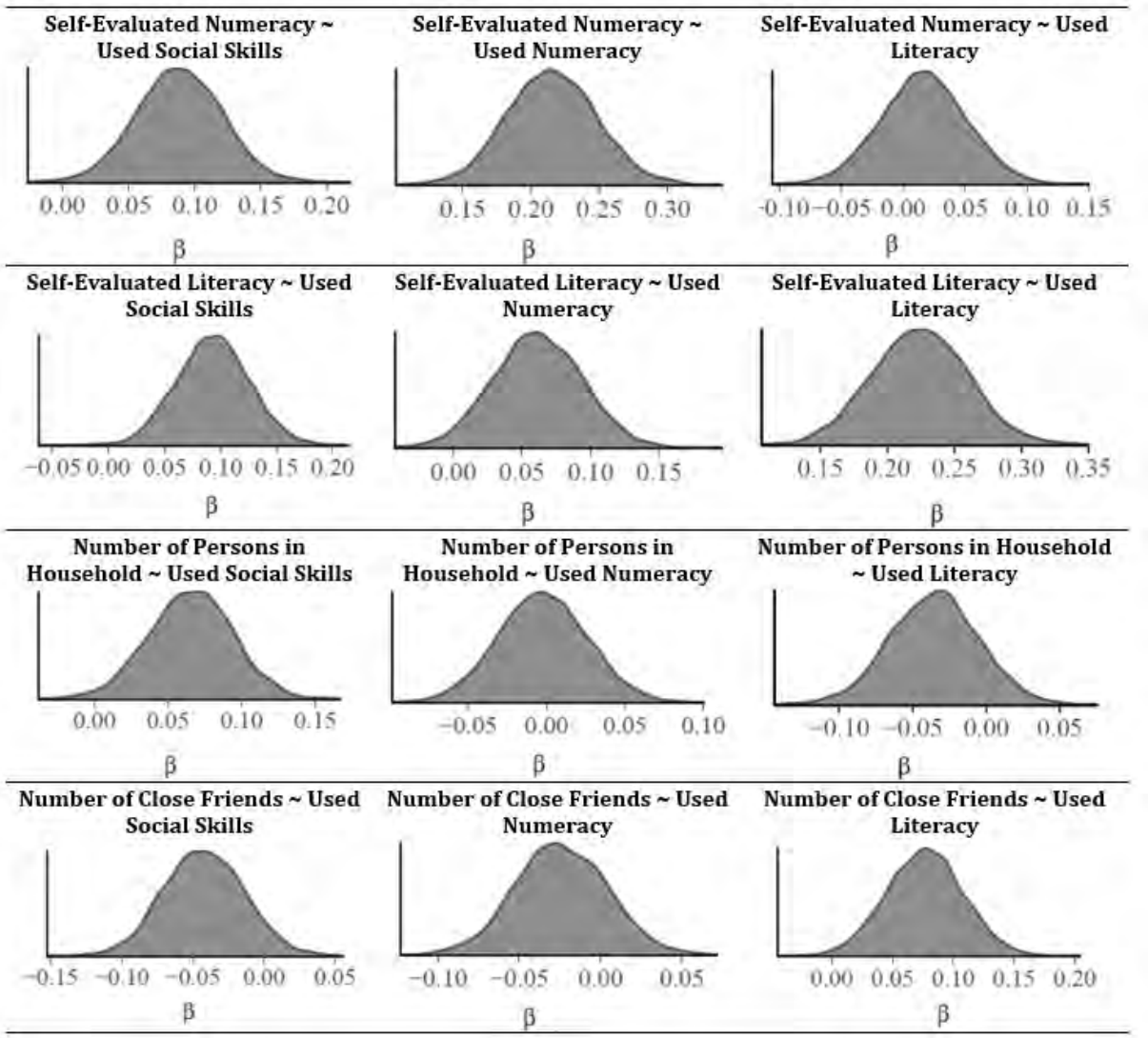


Figure 6. Density Plots

Note. Criterion variables at T3: Self-evaluated numeracy, self-evaluated literacy, number of persons in household, number of close friends; predictor variables at T1: Frequently used social skills, frequently used numeracy, frequently used literacy.

Discussion

The aim of the current study was to give first insights into relationships between adults' frequent use of numeracy, literacy, social skills and their self-evaluated numeracy, literacy, and social lives over time, all while considering several covariates, namely gender, age, numeracy and literacy test scores (plausible values), birth inside or outside Germany (as a proxy for ethnicity), average weekly working hours, and socioeconomic background.

Adults interact with others with varying degrees of frequently and use different skills at work and in their social lives (Freund & Kasten, 2012; Goethals, 1986; Krath et al., 2021; Paulick et al., 2017). Moreover, adults' skills are related to their self-evaluations (Zell et al., 2020; Zell & Krizan, 2014). For example, high levels of numeracy skills in adults are often related to high levels of self-evaluated numeracy (Zell & Krizan, 2014). However, numeracy performance assessments are less frequently available in adults' working and social lives than opportunities for social comparisons with colleagues and others.

The current study was based on Festinger's Hypothesis II (1954, p. 118): "To the extent that objective, non-social frames of reference are not available, people evaluate their opinions and abilities by comparison respectively with the opinions and abilities of others." Thus, frequently used skills at work might be self-evaluated using external or social frames of reference, such as perceived skills of colleagues. The question was whether the frequently used skills and social experiences relate to adults' self-evaluations and social lives over time. The current research focused on the domain-specific basic skills numeracy, literacy, and social skills because these are often required in adults' everyday lives, including work.

The results suggested that (a) adults' frequent use of numeracy, (b) literacy, and (c) social skills are positively related to self-evaluated literacy and (except literacy used) to self-evaluated numeracy over time. (d) Frequent use of social skills at T1 was mildly related to higher numbers of people in household three years later at T3. Frequent use of literacy at T1 was mildly related to more close friends three years later at T3 than less frequent use of literacy. No relationships existed between frequent use of numeracy or literacy at T1 and numbers of people in household three years later at T3.

With regard to the first two findings, it can be noted that strong evidence for a positive relationship between tested skills (test scores) and self-evaluated skills (Zell & Krizan, 2014) suggests corresponding relationships between frequent use of skills and self-evaluations of these skills over time. High numeracy and literacy test scores at T2 were positively related to self-evaluated numeracy and literacy, respectively, as already discussed by Zell and Krizan (2014). The current results of the positive relationships between frequently used numeracy or literacy and corresponding self-evaluations three years later underscore the high importance of using skills in daily life, or at least in frequent trainings to promote learned skills throughout the lifespan. The current results are also in accordance with previous findings from the school context (Marsh, 1987; Marsh et al., 2015; Möller et al., 2009, 2020).

Further covariates besides test scores, such as being a man, also increased the probability of high numeracy self-evaluations. Similar gender effects on self-evaluations are likewise well-known from previous research in the school context (Marsh et al., 2015; Möller et al., 2009).

The relationship between social skills and self-evaluations over time, even when concurrently including frequent use of numeracy and literacy and corresponding test scores, suggests that frequent use of social skills and associated social interactions play a role for self-evaluated numeracy and literacy over time, as Festinger (1954) predicted with respect to the role of "social means" for self-evaluations. Interestingly, frequent use of literacy increased the probability of reporting a higher number of close friends over time. This seems plausible in light of the items used to assess frequent use of literacy, which refer, for example, to writing letters or e-mails in or outside the workplace. Letters and e-mails are forms of social interactions (Papen, 2009; Roshid et al., 2022; Skovholt et al., 2014).

Moreover, the presented results uncovered positive cross-domain relationships between frequently used social domain skills and self-evaluated academic domain skills (i.e., numeracy and literacy) over time. This result implies that social skills used in overall positively perceived interactions with the individuals' social environments (e.g., cooperative learning or fruitful collaborations) were associated with their later numeric and literacy self-evaluations as suggested by Zell et al. (2014). The cross-domain relations also demonstrate the complexity of adults' lives in that their frequently used core skill literacy relates to their social environment (i.e., in the current study the number of close friends). In turn, core skills and transversal skills (OECD, 2021) may be related to indicators of adults' social environments over time. Both, adults' frequently used skills and their social environments may be impaired by interindividual conflicts or pandemic measures linked to high risk of feeling alone. On the other hand, the frequent use of skills might be trained by educational measures to foster adults' skills and social environments throughout their lifespans. Finally, the direction of the presented effects remains unclear, since the current results do not allow for causal interpretations.

Conclusion

The current study highlighted the relationships between adults' social skills and self-evaluated numeracy and literacy over time by a latent Bayesian structural equation model. The presented BSEM may be transferred to other research questions of large-scale assessments. Moreover, adults who frequently used literacy reported higher numbers of close friends over time than those who seldomly used literacy. The findings suggest possible interrelations between adults' social skills, social lives and numeracy and literacy over time. Hypotheses of moderation effects through changes in adults' lives (e.g., death of close relatives or friends, moving to another city or country and having to build a new social network) might be tested in further research.

Recommendations

Using the PIAAC-L data, research might focus on the role of different aged children in a household for woman's vs man's frequently used skills, corresponding performance, self-evaluated skills and work-related variables over time. Another research focus using the PIAAC data might be whether different periods of unemployment impair adults' self-evaluated skills, and if attending education measures moderates this assumed relationship between unemployment and self-evaluated skills. The findings are important for educational contexts (e.g., peer learning among adults) and for research on the effects of distance learning and working with fewer social interactions on adults' social lives, and in turn, on their self-evaluated skills and actual performance under pandemic conditions.

Limitations

The available scientific use files do not provide assessments of all variables at each timepoint. For example, frequent use of skills is only assessed at T1, while self-evaluated numeracy and literacy area only assessed at T3. Unfortunately, self-evaluated social skills were not assessed at all. The self-reported number of persons in adult's household is only available in the data set from 2015. The available nonresponse weights "SPFWT0*bleib_14*bleib_15" for longitudinal analyses with data from T1, T2, and T3 were not included (Burkhardt et al., 2018) due to the longitudinal subsample of working

adults. Conclusions from the current study refer only to this analyzed sample, not to the German population as a whole, meaning that its generalizability is restricted accordingly.

The present work focused on effects of frequent use of domain-specific basic skills, namely numeracy, literacy, and social skills (under consideration of several covariates) on later self-evaluations of numeracy and literacy as well as variables related to individuals' social lives (household size and close friends). Further findings on relationships between social factors and other variables such as problem-solving (Goldhammer et al., 2014), ICT literacy, ICT engagement (Kunina-Habenicht & Goldhammer, 2020), statistical literacy (Gal, 2002), or process variables concerning sourcing in an assessment of multiple document comprehension (Hahnel et al., 2019) would be valuable. Social situations might play an important role for numeracy, literacy, and social interactions, especially during (COVID-19) pandemic conditions requiring social distancing.

Ethics approval and consent to participate: Not applicable

Consent for Publication:

There is a Data Distribution Contract with the Leibniz Institute for Social Sciences (GESIS) that the author has access to the data "*PIAAC-L, Germany [ZA5989]*" and the consent for publication.

Availability of data and materials:

The longitudinal data used in the current study was collected for the large-scale Program for the International Assessment of Adult Competencies (PIAAC) funded by the German Federal Ministry of Education and Research. The data are available as scientific use files on the website of GESIS (https://www.gesis.org/en/piaac/piaac-home/data-and-publications)

Competing Interests:

The author declares that she has no conflict of interest.

Funding: Not applicable

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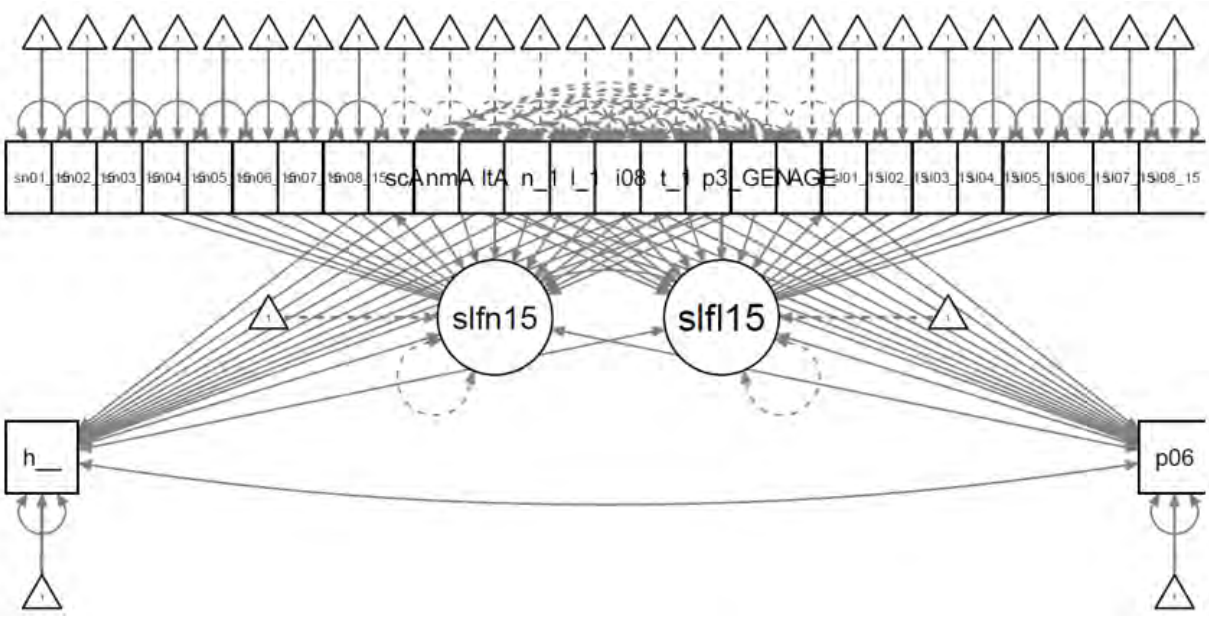
Appendix

Supplemental Table 1. Amounts of Missing Values in Variables Used at Time 1 (T1), Time 2 (T2), or Time 3 (T3)

Variable	Mis	%	M	SD
1 Social Skills Used, T1	764	23	31.43	8.95
2 Numeracy Skills Used, T1	603	19	27.32	9.21
3 Literacy Skills Used, T1	603	19	31.69	7.69
4 Age T1	0	0	40.28	13.87
5 Numeracy Skills Tested, PVs, T2	0	0	2806.54	460.22
6 Literacy Skills Tested, PVs, T2	0	0	2782.91	406.00
7 Weekly Working Hours, T2	891	27	37.27	13.25
8 Numeracy Skills Self-Evaluated, T3	10	< 1	34.26	5.73
9 Literacy Skills Self-Evaluated, T3	25	1	34.61	5.21
10 Number of Persons in Household, T3	0	0	2.62	1.26
11 Number of Close Friends, T3	4	< 1	4.67	4.11
Gender, T1	0	0	-	-
Ethnic Background, T2	155	5	-	-
Socio-Economic Status (ISEI), T3	802	25	48.04	20.21

Note. Numeracy skills and literacy skills tested include plausible values that are available in the scientific use files of PIAAC-L (Rammstedt et al., 2017; Khorramdel et al., 2020). Males were coded as 0. Females were coded as 1. Ethnic background in Germany was coded as 0, out of Germany as 1 (*n* = 3263 adults).



Supplemental Figure 1. Bayesian Structural Equation Model (SEM)

Note. Criterion variables at T3: slfn15 = self-evaluated numeracy, slfl15 = self-evaluated literacy, h_ = number of persons in household, p06 = number of close friends; predictor variables at T1: sociaActs = frequently used social skills, numerActs = frequently used social skills; literActs = frequently used social skills.