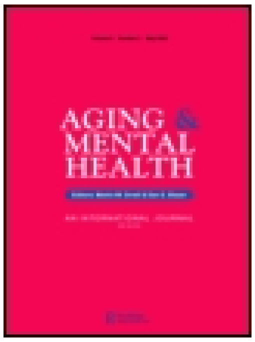

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No cross-sectional evidence for an increased relation of cognitive and sensory abilities in old age[1]

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Objectives: A key question in gerontological research concerns whether good functioning can be maintained in some cognitive abilities in old age, even if deficits occur in other cognitive or sensory abilities. Our goals were to investigate relations of cognitive and sensory abilities in old age, whether these relations differed in size across old age, and whether this was affected by general cognitive ability (processing speed), educational level, and/or general health status.
Methods: Two thousand eight hundred and twelve older adults (aged 65−101, $M = 77.9$ years) from the Vivre−Leben−Vivere survey served as cross-sectional sample for the present study. We administered psychometric tests on processing speed (the speed of cognitive processing), cognitive flexibility (the ability to alternate between cognitive operations), and verbal abilities (vocabulary). In addition, we interviewed individuals on their hearing, eyesight, educational level, and general health status. We regressed sizes of relations between abilities (calculated within each 1-year age tranche) on mean age within the corresponding age tranche, with the number of participants within the corresponding age tranche as case weights.
Results: We observed a decrease in relations between processing speed and cognitive flexibility in old age that was particularly pronounced in individuals with high educational level ($r = -.41$). In contrast, we did not find differences in relations between other cognitive and sensory abilities across old age, which held for different levels of general cognitive ability, education, and general health status.
Conclusion: Present data do not support the view of a generally increased relation of cognitive and sensory abilities in old age.

Keywords: cognitive performance; sensory abilities; older adults

Introduction

A key question in gerontological research concerns whether good functioning can be maintained in some cognitive abilities in old age, even if deficits occur in other cognitive or sensory abilities (Baltes, 1987; Rabbitt, 1993). Conceptually, due to the declining efficiency of sensorimotor functions and neural processes in old age, it has been predicted that cognitive processes become progressively more related to the declining sensory and physiological processes (Balinsky, 1941; Baltes, Cornelius, Spiro, Nesselroade, & Willis, 1980). Evidence for such a pattern comes for example from studies revealing an increase in relations between different cognitive abilities in old age (e.g., Adrover-Roig, Sese, Barcelo, & Palmer, 2012; Hertzog & Bleckley, 2001; Papenberg et al., 2014). However, there are only few studies so far supporting the view of an increase in relations between cognitive and sensory abilities (Baltes & Lindenberger, 1997; Lindenberger & Baltes, 1994). For example, Lindenberger and Ghisletta (2009) found only moderate relations between cognitive and sensory declines in old age and therefore suggested a (at least partly) differential development of the two. In addition, there are several studies that could not confirm the pattern of increasing relations between different abilities in old age at all (e.g., Anstey, Hofer, & Luszcz, 2003; Juan-Espinosa et al., 2002; Park et al., 2002; Zelinski & Lewis, 2003).

This large variety in results debating the potential increase in relations between different abilities in old age strongly suggests that findings may be moderated. First, one could predict that the relations between cognitive abilities differ according to global level of cognitive ability (e.g., Reinert, Baltes, & Schmidt, 1965), with a stronger increase in relations between abilities in old age for low-ability individuals. This assumption has been partly confirmed but overall results are nevertheless mixed (e.g., Anstey et al., 2003; Facon, 2008). Second, different levels of cognitive reserve could act as a moderator of relations between abilities in old age. In general, individuals with shorter and less complex education in early life (and hence less cognitive reserve) show lower performance and greater decline in multiple cognitive abilities in old age (e.g., Gatz et al., 2001; Ihle et al., 2015; Stern, 2002; Tucker & Stern, 2011). Thus, one could assume that those individuals may show a stronger increase in relations between those abilities in old age as overall performance declines. However, no study so far has explicitly targeted this issue in detail. Third, from a psychobiological perspective, general health status in old age may be a marker of more subtle alterations of the brain affecting cognitive

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performance such as reductions in white-matter integrity and volume loss in prefrontal and medio-temporal areas as well as decline in striatal and extrastriatal dopamine systems, which has been discussed as another key moderator of patterns of increasing relations between abilities in old age (e.g., Lindenberger & Ghisletta, 2009; Papenberg et al., 2014).

Taken together, as outlined above, although previous studies put much effort in examining the potential increase in relations between different abilities in old age, three major issues remained inconclusive so far, which will be explicitly targeted in the present work. First, the bulk of literature concentrated on solely cognitive measures and less on other abilities such as the relations between cognitive and sensory abilities. Moreover, results were mixed and thus inconclusive so far (Baltes & Lindenberger, 1997; Lindenberger & Ghisletta, 2009). Second, previous studies focused on comparing relations between different cognitive abilities in rather distant age groups (e.g., older versus younger or middle-aged adults) or did not take a broad overall age range in terms of the full range of old age into account (e.g., Facon, 2008). Thereby, it remained unclear so far whether the potential increase in relations between different abilities depicts a linear (i.e., continuous) or a nonlinear (i.e., accelerated) pattern across old age. Third, previous studies left the role of possible moderators unanswered such as general cognitive ability, cognitive reserve (in terms of educational level), or general health status (e.g., Anstey et al., 2003; Papenberg et al., 2014).

Thus, the present study adopted these three major goals to extend the literature by investigating the pattern of relations between cognitive and sensory abilities in a large sample of older adults with a broad age range (65−101 years) in more detail. Specifically, our first goal was to examine the size of relations between cognitive abilities (i.e., processing speed, cognitive flexibility, and verbal abilities) and sensory abilities (i.e., hearing and vision) in old age. Our second goal was to investigate whether these relations (cross-sectionally) differed in size across the full range of old age and whether this depicted a linear (i.e., continuous) or a nonlinear (i.e., accelerated) pattern. Our third goal was to examine whether this pattern was affected by key moderators in cognitive aging such as general cognitive ability (i.e., performance in processing speed), educational level, and/or general health status.

Methods

Participants

Data were collected in 2011 and 2012 and come from the Vivre−Leben−Vivere (VLV) survey, an ongoing project on vulnerability in Switzerland (LIVES). The main (cross-sectional) sample (of 3080 participants) was randomly selected as a representative sample of the population in the cantonal and federal Swiss administrations' records and stratified by age (65−69, 70−74, 75−79, 80−84, 85−89, and 90+ years), sex, and canton (Bale, Berne, Geneva, Ticino, and Valais). Of them, 2812 cognitively healthy participants performed a test on verbal abilities (see below for further task descriptions) and served as sample for the present study. Two thousand and seventy three performed a psychometric test on processing speed and 1692, a test on cognitive flexibility (see Statistical analyses section for further details). Mean age was 77.9 years (SD = 8.2, range 65−101). Further sample characteristics in terms of proportions regarding canton, sex, and age groups are displayed in Table 1.

Table 1. Descriptive characteristics of the analyzed sample in terms of proportions regarding canton, sex, and age groups.

	Overall $N = 2812$	
Age group	65−69: 549 (19.5%)	70−74: 576 (20.5%)
	75−79: 530 (18.8%)	80−84: 459 (16.3%)
	85−89: 405 (14.4%)	90+: 293 (10.4%)
Sex	Women: 1330 (47.3%)	Men: 1482 (52.7%)
Canton	Bale: 591 (21.0%)	Berne: 662 (23.5%)
	Geneva: 531 (18.9%)	Ticino: 501 (17.8%)
	Valais: 527 (18.7%)	

Note: The proportions regarding age groups are only for descriptive purposes regarding stratification criteria. In all analyses with age as predictor, it was treated as a continuous variable.

Materials

Cognitive abilities

Processing speed. We assessed the Trail Making Test part A (TMT A; Reitan, 1958) measuring processing speed (i.e., the speed of cognitive processing). After seven exercise trails, participants had to connect the numbers 1−25 as fast as possible and without error in ascending order. The processing speed score was derived from the time in seconds needed to connect the 25 numbers and reversed so that higher values represented better performance across all variables.

Cognitive flexibility. We assessed the Trail Making Test part B (TMT B; Reitan, 1958) measuring cognitive flexibility (i.e., the ability to alternate between different cognitive operations). After seven exercise trails, participants had to connect the numbers 1−13 in ascending order and the letters A−L in alphabetic order while alternating between numbers and letters (i.e., 1-A-2-B-3-C … 12-L-13) as fast as possible and without error. The cognitive flexibility score was derived from the time in seconds needed to connect the 25 numbers/letters and reversed so that higher values represented better performance across all variables.

Verbal abilities. We administered the Mill Hill vocabulary scale (Deltour, 1993) measuring verbal abilities (i.e., vocabulary). After one exercise item, participants had to underline the word that semantically matched the target word, which was intermixed with five distractor words. Ten of those vocabulary items were presented, without any time limit. The verbal abilities score was the proportion of correctly completed items.

Sensory abilities

Hearing. As a measure for hearing, we asked participants on a 3-point Likert-type rating scale whether their current hearing allowed them to follow a conversation by choosing one of the following alternatives: 0 = 'no'; 1 = 'yes, but with difficulties'; or 2 = 'yes, without difficulties.'

Vision. As a measure for eyesight, we asked participants on a 3-point Likert-type rating scale whether their current eyesight allowed them to read a newspaper by choosing one of the following alternatives: 0 = 'no'; 1 = 'yes, but with difficulties'; or 2 = 'yes, without difficulties.'

Moderator variables

General cognitive ability. For subsequent moderator analyses, we divided the sample into two groups of high versus low level of general cognitive ability (based on performance in processing speed measured with the TMT A; see above for further task descriptions).

Educational level. Participants were asked to indicate their highest educational level by choosing one of the following six levels: (1) primary school level; (2) inferior secondary school level; (3) apprenticeship graduation; (4) superior secondary school level; (5) technical college or superior vocational college degree; or (6) university degree.

General health status. Participants were asked to rate their current general health status based on a scale ranging from 0 = 'worst imaginable health' to 100 = 'best imaginable health.'

Procedure

A face-to-face questionnaire was administered using the CAPI (computer-assisted personal interview) method. This session contained (besides a larger set of other questionnaires) a socio-demographic survey, the items regarding sensory abilities and health, and the paper–pencil assessment of the cognitive abilities. Participants were individually tested. The experimenter always assured that the participant fully understood and followed the instructions (see Ludwig, Cavalli, and Oris, 2014 for a more detailed description of the VLV survey procedure).

Statistical analyses

For descriptive purposes, we examined age relations of cognitive and sensory abilities (based on the overall sample), with performance in the respective ability regressed on age (testing for linear and quadratic age terms). To follow our first major goal, we calculated bivariate (inter)relations of cognitive and sensory abilities in old age (based on the overall sample). To follow our second major goal, we calculated bivariate (inter)relations of cognitive and sensory abilities within each 1-year age tranche and examined whether their sizes (cross-sectionally) differed across the age tranches in old age and whether this depicted a linear (i.e., continuous) or a nonlinear (i.e., accelerated) pattern. For this purpose, we used weighted regressions, with sizes of relations between the two respective abilities regressed on mean age within the corresponding age tranche (testing for linear and quadratic age terms) and with the number of participants within the corresponding age tranche as case weights. To follow our third major goal, we divided the sample into two groups of high versus low level of general cognitive ability (based on performance in the TMT A), education, and general health status, respectively (i.e., for each moderator separately). We then calculated bivariate (inter) relations of cognitive and sensory abilities separately for the two levels of the respective moderator within each 1-year age tranche and examined their differential patterns across old age. For this purpose, we used weighted regressions, with sizes of relations between the two respective abilities regressed on mean age within the corresponding age tranche (testing for linear and quadratic age terms) plus the respective moderator variable (high vs. low level) plus an interaction term of age and the respective moderator and with the number of participants within the corresponding age tranche of the respective moderator level as case weights. Note that for the two latter goals, we investigated the functional nature of the inspected patterns on a fine-grained level based on 1-year age tranches across more than three decades in old age. These age tranches contained 58.3 individuals on average. To take into account that estimations of relationships are in general more reliable in larger samples, we conducted weighted regression analyses (with the number of participants per tranche as case weights).

In all analyses with age as predictor, it was treated as a continuous variable. For all relations with hearing or vision, we calculated Spearman's ρ. For the interrelations of the cognitive abilities, we calculated Pearson's correlation coefficients r. We calculated relations with processing speed based on 2073 participants, relations with cognitive flexibility based on 1692 participants, and all other relations based on 2812 participants. Note that in the extensive survey procedure, we had administered the cognitive tests only if there was enough time left (allowing a proper administration of the verbal abilities test in 2812 participants). Note that we had administered the processing speed test only if the participant had properly performed all seven exercise trails. Likewise, we had administered the (more complex) cognitive flexibility test only if the participant had properly performed the processing speed test as well as all seven exercise trails of the cognitive flexibility test. Furthermore, we terminated the processing speed and the cognitive flexibility test (without any score) when the individual made any error in connecting the 25 numbers/letters in the respective test (allowing a proper administration of the processing speed test in 2073 participants and of the cognitive flexibility test in 1692 participants). Note that we applied these restrictive criteria to be able to directly compare reaction times (i.e., reaction times would be confounded when including participants that made errors and took additional time to correct them). Due to these restrictive criteria, the remaining sample was slightly younger, better educated, healthier, and contained a larger proportion of men, compared to the main sample ($ps < .044$). For all analyses, the *R* environment was used.

Results

Descriptive statistics

Mean cognitive and sensory performance

Table 2 shows means and standard deviations of performance in cognitive and sensory abilities (based on the overall sample). There were no effects of sex or canton on cognitive and sensory performance (all $ps > .121$).

Age relations of cognitive and sensory abilities

For all cognitive and sensory abilities, higher age was significantly related to lower performance (see Table 3 for an overview). Cognitive flexibility and vision showed a nonlinear age relation, with both age terms being significant. Processing speed, verbal abilities, and hearing showed a nonlinear age relation, with the quadratic age term being significant and no further contribution by additionally entering a linear age term (all $ps > .112$).

Examining relations between abilities in old age

Analyses regarding our first major goal revealed that all relations between cognitive and sensory abilities were significant but differed in size (see Table 4 for an overview). The largest relation was found between processing speed and cognitive flexibility. Relations of verbal abilities with processing speed and cognitive flexibility were of medium size. Relations of cognitive abilities with sensory abilities as well as between the two sensory abilities were only of small size.

Table 2. Means and standard deviations of performance in cognitive and sensory abilities (based on the overall sample).

Variable	*M*	SD
Processing speed	66.20 (seconds)	30.61 (seconds)
Cognitive flexibility	127.59 (seconds)	52.66 (seconds)
Verbal abilities	59.4 (percent correct)	25.7 (percent correct)
Hearing	1.77 (rating)	0.47 (rating)
Vision	1.85 (rating)	0.43 (rating)

Note: Means and standard deviations of performance in cognitive and sensory abilities, based on 2073 participants for processing speed. Higher values represented better performance across all variables.

Table 3. Age relations of cognitive and sensory abilities (based on the overall sample).

Variable	Linear	Quadratic	Total
Processing speed	ns	$-.38^{***}$	$-.38^{***}$
Cognitive flexibility	$.77^{*}$	-1.18^{**}	$-.41^{***}$
Verbal abilities	ns	$-.18^{***}$	$-.18^{***}$
Hearing	ns	$-.21^{***}$	$-.21^{***}$
Vision	$.98^{**}$	-1.20^{**}	$-.22^{***}$

Note: Age relations of cognitive and sensory abilities (based on the overall sample), with performance in the respective ability regressed on age (testing for linear and quadratic age terms). If the age relation was not better described by models containing both a linear and a quadratic age term, only the model with the single age term is reported that descriptively explained more age variance. Age was treated as a continuous variable. Linear = relation coefficient of the linear age term. Quadratic = relation coefficient of the quadratic age term. Total = resulting total age relation that is accounted for by the linear and the quadratic age term. Higher values represented better performance across all variables.
$^{***}p < .001$; $^{**}p < .01$; $^{*}p < .05$; ns = non-significant, $p > .05$.

Examining differences in relations between abilities across old age

Analyses regarding our second major goal revealed that the relations between processing speed and cognitive flexibility showed a linear age-related decrease in size across the age tranches in old age (see Table 5 for an overview), with no further contribution by additionally entering a quadratic age term ($p = .456$). All other (inter)relations of cognitive and sensory abilities did not differ in size across old age, neither with a linear age term (all $ps > .111$), nor by additionally entering a quadratic age term (all $ps > .290$).

Moderator analyses

Analyses regarding our third major goal revealed that examining educational level as moderator, the previously observed linear age-related decrease of relations between processing speed and cognitive flexibility across the age tranches in old age held only for the high-level subgroup ($r = -.41$, $p = .046$) but not for the low-level subgroup ($r = .19$, $p = .383$). This reflected a significant interaction of educational level with age ($p = .033$). This analysis also revealed that relations between processing speed and cognitive flexibility were of larger size in the high-level

Table 4. Relations between abilities in old age (based on the overall sample).

Variable	1	2	3	4	5
(1). Processing speed	–				
(2). Cognitive flexibility	$.63^{***}$	–			
(3). Verbal abilities	$.24^{***}$	$.27^{***}$	–		
(4). Hearing	$.10^{***}$	$.11^{***}$	$.09^{***}$	–	
(5). Vision	$.18^{***}$	$.15^{***}$	$.09^{***}$	$.07^{*}$	–

Note: Full correlation matrix regarding the bivariate relations between abilities in old age (based on the overall sample). Higher values represented better performance across all variables.
$^{***}p < .001$; $^{*}p < .05$.

Table 5. Differences in relations between abilities across old age.

Variable	1	2	3	4	5
(1). Processing speed	–				
(2). Cognitive flexibility	−.43*	–			
(3). Verbal abilities	.02 ns	−.05 ns	–		
(4). Hearing	.05 ns	−.22 ns	−.04 ns	–	
(5). Vision	.33 ns	.02 ns	.04 ns	−.30 ns	–

Note: Matrix of age-regression coefficients indicating whether bivariate relations between the two respective abilities differed across the age tranches in old age, with sizes of relations between the two respective abilities regressed on mean age within the corresponding age tranche (testing for a linear age term) and with the number of participants within the corresponding age tranche as case weights. As all age differences were not better described by models containing both a linear and a quadratic age term, only the regression coefficients of the respective linear model are reported. Age was treated as a continuous variable. Higher values represented better performance across all variables.
*$p < .05$; ns = non-significant, $p > .05$.

compared to the low-level subgroup ($p = .030$). For general health status as moderator, the previously observed linear age-related decrease of relations between processing speed and cognitive flexibility across the age tranches in old age was present in both subgroups ($r = -.42$, $p = .038$), with no main effect of general health status ($p = .121$) and no interaction with age ($p = .141$). For these two moderator models, there was no further contribution by additionally entering a quadratic age term (all *p*s > .299). Besides that, the previously observed patterns of stability in (inter)relations of the other cognitive and the sensory abilities across the age tranches in old age were not moderated by general cognitive ability, educational level, nor general health status (all *p*s > .225).

Discussion

Our first major goal was to examine the size of relations between cognitive abilities (i.e., processing speed, cognitive flexibility, and verbal abilities) and sensory abilities (i.e., hearing and vision) in old age. Present results suggest that in old age relations between different cognitive abilities are of medium to large size, while relations between cognitive and sensory abilities are only of small size.

Our second major goal was to investigate whether these relations (cross-sectionally) differed in size across old age and whether this depicted a linear (i.e., continuous) or a nonlinear (i.e., accelerated) pattern. Present results suggest that (inter)relations of cognitive and sensory abilities (apart from relations between processing speed and cognitive flexibility, see below) do not differ in size across old age, but instead remain stable until old−old age. These results corroborate several studies that did not support the view of an increase in relations between abilities in old age (e.g., Anstey et al., 2003; Juan-Espinosa et al., 2002; Zelinski & Lewis, 2003). Notably, present data suggest that this pattern also transfers to relations between cognitive performance and different indicators of sensory abilities and thus consistently speaks against the view of a generally increased relation of cognitive and sensory abilities in old age. This confirms findings of Lindenberger and Ghisletta (2009) who found only moderate relations between cognitive and sensory declines in old age and thereby supports the view of an (at least partly) differential development of the two.

For the relation between processing speed and cognitive flexibility in old age, data suggest a linear (i.e., continuous) decrease in relations across the age tranches in old age. These results are in line with the view that an increase in relations between abilities in old age may not be evident unless trends of age-related development in the inspected abilities converge in old age, which may be most likely for process-overlapping tasks (e.g., Hertzog, 1989; Rabbitt, 1993). This would for example be the case when the inspected abilities are strongly affected by age decline in processing speed (e.g., Hertzog, 1989; Hertzog & Bleckley, 2001). In contrast, if the inspected cognitive abilities show a differential development in old age, these disparate age trends would cause those abilities to remain (or become) differentiated in old age. Specifically, one possible pattern may be stability in relations between abilities (e.g., Hertzog, Dixon, Hultsch, & MacDonald, 2003; Juan-Espinosa et al., 2002). As we did not find converging age trends for cognitive and sensory abilities, present results of stability in relations confirm those latter findings. Notably, there is evidence that disparate age trends could even result in a further differentiation of abilities in old age (e.g., Park et al., 2002), as corroborated by the present finding of a decrease in relations between processing speed and cognitive flexibility in old age. This seems reasonable given that in general, processing speed and cognitive flexibility show a differential age-related development. In the present study, both processing speed and cognitive flexibility followed a nonlinear (i.e., accelerated) negative age relation across old age. However, compared to the (more basic) processing speed task, for the (more complex) cognitive flexibility task there was a particularly pronounced sharp gradient in old−old age (with a nonlinear component that was three times as much compared to that of processing speed), possibly because of the extra processes required to cognitively control alternating between cognitive operations to properly perform the task (e.g., Mayr & Liebscher, 2001).

Our third major goal was to examine whether the pattern of relations between cognitive and sensory abilities across old age was affected by key moderators in cognitive aging such as general cognitive ability (i.e., performance in processing speed), educational level, and/or general health status. Present results showed that the observed linear (i.e., continuous) decrease in relations between processing speed and cognitive flexibility in old age (held for different levels of general health status, but) was moderated by educational level. The age-related decrease in relation sizes across the age tranches in old age held only for the high-level but not for the low-level subgroup. This may suggest that for the high-level subgroup, the larger cognitive reserve (built up by longer and/or more complex education in early life; e.g., Stern, 2002) helps to maintain a relatively good performance in both processing speed and cognitive flexibility in young−old age, which would explain the finding of larger relations between both cognitive abilities for better educated individuals. Later in old−old age, this effect of educational level may become differential, i.e., more pronounced in some cognitive abilities than in others (e.g., because of an individual's amount of cognitive reserve may be sufficient to support the more basic processing speed even in old−old age, but instead only to a smaller extent the more complex cognitive flexibility). This would then possibly cause and/or intensify differential age trends resulting in the pattern of ability differentiation in old age for better educated individuals. Although speculative, these thoughts may further motivate future research to specify the detailed mechanisms underlying the interaction of educational level with differences in relations between abilities in old age. Besides that, although a particularly strong increase in relations between abilities in old age could be expected in individuals with lower levels of general cognitive ability, cognitive reserve (in terms of educational level), and/or general health status (e.g., Anstey et al., 2003; Facon, 2008; Papenberg et al., 2014), evaluating such effects in detail, we did not find any sign of such an increase in any of these moderator subgroups. This further underlines the need for future research to identify and specify the conditions under which an increase in relations between abilities in old age may become particularly evident.

Limitations of the present study concern the following issues. We acknowledge that the present study is limited by its cross-sectional design that does not allow for causal inferences. Present analyses give only information about age differences but do not allow drawing conclusions regarding intra-individual changes over time. However, present results are in line with a number of longitudinal studies showing also no increase in relations between abilities in old age (e.g., Anstey et al., 2003; Zelinski & Lewis, 2003). Moreover, we acknowledge that due to the restrictive criteria for the processing speed and the cognitive flexibility test, there was a certain selection of the remaining sample. It may be possible that participants who properly did the test had a better cognitive status and may show a different pattern of longitudinal change than those who made an error. Thus, future research may explicitly target to evaluate whether the present findings on a fine-grained cross-sectional level hold also regarding multiple measures of cognitive and sensory change over time and whether this differs in individuals who suffer clinical change. In addition, hearing, vision, and health status had only been assessed using subjective measures, which may have limited reliability and validity. Hence, future studies may also include objective measures for visual acuity, auditory threshold, and physiological health indicators.

Regarding the concern that estimations of relations were not reliable because not having enough participants per tranche, too narrow age range within the tranches, restricted variance, and/or low reliability of the administered tests, four things should be noted: First, the derived age tranches contained 58.3 individuals on average, allowing a reliable estimation of parameters. To take into account that estimations of relationships are in general more reliable in larger samples, weighted regression analyses with the number of participants per tranche as case weights were conducted. Using the square root of N or the respective standard errors of the relations as case weights or applying classical (non-weighted) regressions in additional analyses revealed the same pattern of results. Second, analyses were repeated using larger tranches (i.e., 5-year and 10-year age tranches) to obtain more reliable estimates by minimizing sampling variability, which revealed the same pattern of results. Third, the absence of larger relations in old age is not due to restricted variance within the different abilities as we found that variances were even larger in old age, which is in line with the literature (e.g., Rabbitt, 1993). Fourth, all cognitive measures represented widely used tests with good psychometric properties (Mill Hill, Deltour, 1993; TMT, Reitan, 1958) and the large relations (also on the 1-year-age-tranche level) observed between processing speed and cognitive flexibility indicate that the applied measures were sensitive to detect relations between abilities.

Moreover, one may argue that there would not be any marked increase in relations between abilities until old−old age where even differential age declines have caused more pronounced impairments in a larger set of abilities. However, present results based on participants up to 101 years of age did not show any sign of such a pattern, though overall lower performance. This corroborates the view that functioning may be maintained in some abilities in old age, even if deficits occur in other abilities (Baltes, 1987; Rabbitt, 1993). Importantly, with respect to the present data, this may hold for different levels of general cognitive ability, education, and general health status and thereby may be possibly independent of more global aspects of vulnerability to age impairments.

In conclusion, all in all, present data do not support the view of a generally increased relation of cognitive and sensory abilities in old age. Relations are only of small to medium size and it may be more likely to observe stability or even a further differentiation of abilities in old age, possibly driven by differential trajectories in aging.

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Disclosure Statement

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