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Aging and Imagery: Does Aging affect Imagery Ability?

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Abstract

Mental imagery has a rich history of research in psychology, and its applications are gaining more and more interest. It is used in scientific research, clinical settings and sports. Aging is an important topic in society, for human well-being but also economically. In recent years the scientific view on aging is changing in a more positive way, for instance there could be less brain shrinkage than formally thought and we think about the possibilities of successful aging. In the current study we combined both issues. We investigated the relation between aging and imagery. Imagery can be thought of as the re-creation of perceptual experiences, that is why elderly could be at an advantage because they gathered more experiences. Today it is believed that the pure impact of "normal" aging on cognitive functions could be less disabling than formerly thought. Some cognitive functions remain stable, such as general knowledge, while other cognitive functions even improve with age, like making good strategic use of facts. So we expected positive relations between aging and imagery abilities. This study examined 273 participants of the general population in a continuous age group of 18 to 65 years (m = 39.4) via online self-report questionnaires. We used Spearman's rho correlations to explore the relation between age and visual, auditory and motor mental imagery. Positive significant relations were found between age and the vividness of visual imagery, VVIQ, $r_s = .13$, $p < .05$, and age and auditory imagery BAIS-VC, $r_s = .18$, $p < .01$. Motor imagery showed no significant relation with age, VMIQ-EIK, $r_s = -.01$, $p > .05$. Thus, with increasing age the vividness ratings of visual and auditory imagery increase, and the elderly experience the vividness of their motor imagery as vividly as younger participants. When we explored the effect of age groups on visual, auditory and kinesthetic imagery it appeared that in all age groups the visual and auditory imagery vividness ratings were significantly related, but not the kinesthetic. The current study suggests that imagery is a powerful, optimistic, non-invasive, inexpensive tool that can be used in all kinds of imagery-based interventions for the elderly.

Introduction

Imagery

Mental imagery is a daily human companion; it is part of all kinds of daily mental processes. Mental imagery can be thought of as the re-creation of perceptual experiences across sensory modalities (Kosslyn, Ganis, & Thompson, 2001) and it is involved in our conscious awareness. Mental imagery occurs when perceptual information is accessed from memory or perception itself. Having a mental image is the conscious experience of seeing with the mind's eye, hearing with the mind's ear, moving the body in one's mind. This inner sensory sensation (imagery) differs from person to person, like Kosslyn et al. (2001) said: "It is a private affair". Because only the "owner" of the inner sensations experiences them, the essence of imagery lies in its phenomenological character (Galton, 1883). Although imagery is thought of as a re-creation, it is never purely reproductive, it is constructive, imaginative and creative (Kosslyn et al., 2001). So imagery is an individual inner conscious experience (Galton, 1883).

Imagery is multidimensional concept. The imagery phenomenon seems to reflect two general classes of abilities (Kosslyn, Brunn, & Cave, 1984). Firstly, there is the ability to use images to retrieve information from memory or perception about the sensory properties of objects. We generate, inspect and maintain these images and experience their vividness. According to Baddeley and Andrade (2000) vividness reflects the extent to which detailed sensory information is available, whether from short-term storage of recent perceptions or from long-term memory. The second ability is to use imagery in the course of thinking. This ability performs image transformations (Kosslyn et al.,1984). In this way we exercise control over the image, by altering it. We create dynamic images, complex sounds or we move objects.

Individual differences in imagery abilities have effect on the effectiveness of imagery (Marks, 1989). People differ in the extent to which they rate their vividness of and their control over their image. Besides the imagery experience there is the individual difference in spontaneous use of imagery sometimes involuntary, sometimes voluntary as a strategy. The use of imagery as a strategy is the functional use of imagery to achieve cognitive goals. People do this every day. This functional use is often part of an individual cognitive style. We can prefer strategies that are linguistically based, i.e. represented in words, or imagery based, i.e. represented in mental pictures, to reach our goals or solve our problems. So imagery can be a mediator, for learning, for remembering, for drawing or for enhancing the generation of alternatives by problem solving (Vecchi & Bottine, 2006).

Imagery is increasingly used in health settings. Mental imagery is a method that can give personal control and is relatively simple and cheap. Modern imagery research addresses, among others, successful living, successful aging and sports. For instance; imagining a brighter future (Murphy, O'Donoghue, Drazich, Blackwell, Nobre, & Holmes, 2015), optimism (Blackwell, Rius-Ottenheim, Schulte-van Maaren, Carlier, Middelkoop, Zitman, Spinhoven, Holmes, & Giltay, 2013), mnemonics (bizarreness effect, the tendency that to-be-remembered information associated with bizarre imagery improves memory performance; Black, McCown, Lookadoo, Leonard, Kelley, DeCoster, Wayde, & Spence, 2012), human navigation (Piccardi, Nori, Palermo, Guariglia, & Giusberti, 2015), public speaking anxiety (Homer, Deeprose, & Andrade), expectation-related mechanisms (Benedetti, Arduino, Costa, Vignette, Tarenzo, Rainero, & Asteggiano, 2006), creative thinking (González, Campos, & Perez, 1997), motor based skill acquisition (Kraeutner, Keele, & Boe), observational learning (Lawrence, Callow, & Roberts, 2013), mental time travel (D'Argembeau & Van der Linden), implicit motor learning (Liao, & Masters, 2001) and, basketball shooting (Lam, Maxwell, & Masters, 2009). Another important part of imagery research is about understanding and treatment of mental- and physical disorders, for instance Post Traumatic Stress Disorder (Holmes, Grey, & Young, 2005), Social Phobia (Hirch, Clark, & Mathews, 2006), Schizophrenia (Malcom, Picchioni, & Ellett, 2015), Depression (Patel, Brewin, Wheatley, Wells, Fishet, & Myers, 2007), Bipolar Disorder (Holmes, Geddes, Colom, & Goodwin, 2008), pain disorders (Berna, Tracy, & Holmes, 2012), Phantom Limb pain (Maclver, Lloyd, Kelly, Roberts, & Nurmikko, 2008), rehabilitation of paralysis after stroke (Kleynen, Wilson, Jie, Te Lintel Hekkert, Goodwin, & Braun 2014), movement rehabilitation in Parkinson Disease (Abbruzzese, Avanzino, Marchese, & Pelosin, 2015) and prospective memory rehabilitation in Traumatic Brain Injury (Potvin, Rouleau, Sénéchal, & Giguère, 2011). For the last five examples the primary consumers of these interventions are presumably the elderly.

Aging

Cognitive functions decline with age. But in recent years scientific ideas and research topics about aging and cognitive abilities are changing. It is not all about the loss of memory, concentration, decline of mental speed. Burgmans, Jolles, & Uylings, (2010) propose that cognitive decline in elderly could be overrated in scientific studies. The Maastricht Aging Study (MAAS) (Burgmans, Van Boxtel, Vuurman, Smeets, Gronenschils, & Uylings, 2009) longitudinally followed a group of healthy elderly. They found an effect of age on brain volume: older people had smaller brains than younger people. It appeared that when participants, who experienced extreme cognitive decline within a few years after the MRI-scan, were removed from the study, the significant age effect on brain size disappeared. So it seems that participants with a "suspicious cognitive profile" (for instance preclinical dementia) could explain the age effect. Because many studies of healthy aging didn't follow the participants over the years the age-effect could be overrated (Burgmans et al., 2010). Today it is recognized that there are many factors for instance diseases, such as Alzheimer's disease or cardiovascular diseases, inflammation, genes (different genes may influence cognition at different ages), diet and lifestyle (being active, drinking, smoking) and intelligence, especially childhood intelligence, that influence the individual differences in cognitive aging (Deary, Corley, Gow, Harris, Houlihan, Marioni, Penke, Rafnsson & Starr, 2009). So considering al these influences and their even possible reverse causation (with prior cognitive ability causing the supposed "cause" of cognitive ability in old age), the pure impact of "normal" aging on cognitive functions is not yet clear and it could be less disabling then formerly thought.

There even are cognitive functions that remain stable (e.g. verbal ability and general knowledge, Deary et al., 2009) and improve when we get older. It seems that older individuals have a relative advantage to younger individuals on tasks that demand experience and knowledge. Social intelligence and making good strategic use of facts are cognitive skills that improve with age (Sapolsky, 2004). Sapolsky (2004) also states that without time stress older people can do as well as younger people. Recent research suggests that older people don't use their brains less, but differently (Grady, 2008, in Brugmans et al., 2010). Black et al. (2012) found no age difference in the susceptibility to the bizarreness effect (a mnemonic to associate to-be remembered information with bizarre imagery). Participants had to form (bizarre) images of unrelated sentences. It appeared that older adults could take advantage of secondary distinctiveness, the degree to which an event is unique relative to past experiences. The bizarre image had an advantage because of its lack of overlap with other images in long-term memory not because of it vividness in working memory. So older people choose a strategy that fits them best.

Imagery and aging

Imagery ability differs between people, which might be related to cognitive function or experience (or both). In imagery it is all in the mind. A mental representation could be visual-, auditory-, kinesthetic (movement)-, olfactory (smell)-, gustatory (taste)-, cutaneous (touch)- or organic (feeling or emotion). The vividness of the image is the most investigated aspect of the image. It seems that long-term memory plays an import role in the vividness of imagery and the role of working memory is limited. Vividness should not be related to the amount of information people can actually recall. Vivid images are those that are accompanied by a feeling that more information can be retrieved if needed (Baddeley, & Andrade, 2000). Experiences seem to influence vividness of and control over the mental image. Di Corrado, Guarnera, and Quartiroli (2014) found that skilled dancers and karatekas had higher mean scores on motor-and visual imagery ability (vividness and control) than a non-athletes group. The results of Aleman, Nieuwenstein, Blöcker, and De Haan (2000) study suggest that musical training may improve both musical and auditory imagery but not visual imagery. In their study of 1994 Isaac and Marks found that trained athletes in general experience more vivid imagery in the motor and visual modalities than non-athletes matched controls.

It is currently unknown how imagery ability develops over the life-span. It is possible that elderly, who lived their lives for a longer time than young people and consequently could gather more experiences, are at an advantage in rating the vividness of an image. Baddeley and Andrade (2000) argue that there could be other determinants of the self ratings of the vividness of an image than working memory and long-term memory. They speculate that greater vividness ratings are accompanied by the feeling that more sensory details of a representation can be accessed, but this information is not necessarily accurately remembered information. People could profit from information from their generic and semantic knowledge. These are cognitive abilities that remain or improve with age. So it could be argued that the elderly report greater vividness than younger people on the base of their experiences and/or their general knowledge.

Imagery ability is not general or undifferentiated, rather it is a number of relative independent sub-abilities that give rise to different mental operations (Kosslyn, Brunn, Cave, & Wallach, 1984). Dror and Kosslyn (1994) found that elderly had relatively impaired image rotation, but their ability to compose (the process of generating the segments of a shape one by one) and scan an image was as good as in young adults. These changing imagery abilities over the life-span could have influence on the development of specific imagery modalities with age.

The aim of the current study is to investigate the relation between aging and imagery against the backdrop of the above-mentioned changing views on aging and our insights about imagery, and the potential use of imagery in health settings. Most studies have been carried out with specific age groups: either young, old or discrete groups of young and old participants. To our knowledge the complete continuum has not previously been investigated in previous studies. Elderly people are a relatively growing part of the (medical) population. So for future scientific research it is very important to know more about the relation between aging and imagery. As such the main research question is whether there is a relationship between general imagery abilities and age.

Mental imagery can occur in any sensory modality. Previous research suggests that the modalities form separated abilities rather than a single, unified imagery ability. Imagery in different modalities can exercise different influences (Andrade, 2014). Imagery for feelings and emotions has been associated with health anxiety (Muse, McManus, Hackmann, & Williams, 2010), kinesthetic and somatic imagery are recognized as playing an important role in movement learning (Cross, Kraemer, Hamilton, Kelley, & Grafton, 2009), hotspots in post-traumatic stress disorder, the parts of the trauma memories that cause high level of emotional distress, also include vivid auditory and organic (feeling and emotion) imagery (Holmes, Grey, & Young, 2004) and frequent vivid gustatory (taste) imagery and olfactory (smell) imagery is associated with substance craving (May, Andrade, Panabokke, & Kavanagh, 2004).

A secondary question we will address is whether there are varying strengths and/or weaknesses in the use of specific sensory modalities and we will address their mutual relations depending on age. To our knowledge this question has not yet been investigated. As there are no previous studies investigating this, this issue will be addressed in an exploratory fashion. This can give us information about the best way to use one or a combination of modalities in therapy and other imagery applications for the elderly, in the light of the hypothesis, that there might be a relation between aging and imagery.

Self-reports

Imagery is complicated because it is hard to measure. Very often self-report questionnaires on imagery experience with simple rating scales are used to make comparisons possible. The current study is based on such self-report questionnaires, which may have certain limitations. However based on the conclusions of the experiments of Baddeley and Andrade (2001) about working memory and vividness of imagery and the experiment of Cui, Jeter, Yang, Montague and Eagleman (2006) we can be confident to do so. Baddeley and Andrade (2001) performed a series of seven experiments. They used the working memory framework to investigate the phenomenological experience of vividness in visual and auditory imagery. This framework assumes a working memory system comprising three major components. The central executive, a limited capacity attentional control system and two subsidiary slave systems: the visuospatial sketchpad and the phonological loop. The visuospatial sketchpad is assumed to maintain and manipulate visual information and to be involved in visual imagery. The phonological loop performs a similar function for auditory and verbal material. Dual task procedures have been shown to disrupt the visuospatial sketchpad and the phonological loop (in Baddeley & Andrade, 2000). All seven experiments showed the predicted interaction between image modality and the verbal or spatial nature of the concurrent activity. The fact that the results of the seven experiments were mostly robust and consistent supports the idea that self rating data are at least as stable and reliable as memory performance data (Baddeley, & Andrade, 2000).

Further support is offered by Cui et al. (2006), who reported that self-reported visual vividness shows a correlation with the early visual cortex activity relative to the whole brain activity. The participants rated their vividness on the Vividness of Visual Imagery Questionnaire (VVIQ) (Marks, 1973). Using functional Magnetic Resonance Imaging (fMRI), brain activity was measured while participants were blindfolded and performed a visualization task by visualizing themselves or another person either bench pressing, or stair climbing while being scanned. Taken together, these results offer sufficient grounds for the use of self-report imagery measures in the current study.

Method

The current study was performed in collaboration with another research project: “Placebo-related effects, expectation and imagery”. Together the ethics of these two projects were approved by the local ethical committee to the Commissie Ethiek Psychologie, Leiden, application number CEP 16-0226/99.

Participants

The participant group size is *n* = 273, with an age rang from 18 to 65, (mean age 39.4 years, *SD* = 14.2), 177 females, 96 males. The participants were either students of the University of Leiden or recruited from the community by the researchers by means of Facebook, e-mail and leaflets. Participants were all Dutch speaking. Among the participants 11 gift vouchers were be raffled (1x€100 en 10x€10).

Apparatus and materials

The questionnaires were distributed via Qualtrics (Provo, UT), a web-based survey tool.

Questionnaires

For this study we used Dutch self-report questionnaires, which have not yet been used in the Netherlands. We will explore three imagery modalities (visual-auditory-and motor), with lists that explore different imagery dimensions (vividness, control, strategy), as well as spontaneous and effortful imagery types. Five separate lists were used:

Spontaneous Use of Imagery Scale (SUIS) (Reisberg, Pearson, & Kosslyn, 2003): the SUIS is used to measure the tendency to spontaneously use visual mental imagery. This scale is a 9-item, Flemish validated questionnaire containing a 5-point Likert response scale ranging from 1-never appropriate (Nooit van toepassing) to 5-always completely appropriate (Altijd van toepassing) and has an acceptable internal consistency. We made some minor edits intended for Dutch rather than Flemish participants, and excluded item one four and six because they did not adequately measure the overall imagery factor according to the validation paper.

Involuntary Musical Imagery Scale (IMIS) (Floridou, Williamson, Stewart & Müllensiefen, 2015): the IMIS is used to measure the individual differences in involuntary musical imagery

(INMI). Participants are asked to rate their experiences with involuntary musical imagery, (so-called earworms). We made our own translation with back-translation, meeting formal criteria of questionnaire translation. The resulting scale is a 15-item in Dutch unvalidated self-report questionnaire containing a 5-point Likert response scale from 1-never (Nooit) to 5-always (Altijd). The English scale is reliable and validated (Floridou et al., 2015).

Bucknell Auditory Imagery Scale (BAIS, Halpern, 2015): the BAIS is used to measure rated vividness and control for musical, verbal and environmental sounds, using two subscales, BAIS V and BAIS C. We made our own translation with back-translation. The resulting scales are two 14-item, in Dutch unvalidated self-report questionnaires for vividness and image changeability ('control'), containing a 7-point Likert response scale, ranging from 1-no image whatsoever (Geen enkele voorstelling of beeld) to 7 -as vivid as the actual sound (Zo helder als echt geluid) to rate the vividness of the image and a 14-item questionnaire containing a 7-point Likert response scale, ranging from 1-no image whatsoever (Geen enkele voorstelling of beeld) to 7-very easy to change the image (Buitengewoon gemakkelijk het beeld te veranderen) to rate the ease of changing one's image of the original sound to a new one. In collaboration with the author, we changed item 6 of the BAIS V from a basketball game to a soccer game (more common in the Netherlands) and item 8 of the BAIS V from Beethoven's Fifth to a symphony (to avoid unfamiliarity for all the participants). The English scale has good reliability.

Vividness of Movement Imagery Questionnaire-2 (VMIQ2, Roberts, Callow, Hardy, Markland & Bringer, 2008): the VMIQ2 is used to measure each participant's rated vividness of the imaged activity as if they are watching themselves doing the movement (External Visual Imagery, E), to measure each participant's rated vividness of the imaged activity as if they are looking out through their own eyes (Internal Visual Imagery, I) and to measure each participant's rated vividness of how it feels to image themselves doing the movement (Kinesthetic Imagery, K). We adjusted an existing, unvalidated Dutch version. This scale exists of three (E, I, K) 12-item, unvalidated self-report questionnaires containing a 5-point Likert response scale, ranging from 1-completely clear (Volkomen helder en duidelijk (zoals de werkelijkheid)) to 5-no image at all (Geen enkele voorstelling, ik weet alleen dat ik aan de beweging denk). The English scale is psychometrically validated.

Vividness of Visual Imagery Questionnaire (VVIQ, Marks, 1973): the VVIQ is used to measure the individual vividness of visual imagery. We adjusted an existing, Dutch unvalidated translation. This scale is a 16-item, in sets of four different scenes, unvalidated self-report questionnaire containing a 5-point Likert response scale from 1-completely clear (Volkomen duidelijk en zo helder als in het echt) to 5-no image, just 'know' you are thinking of something

(Geen beeld, u 'weet' alleen dat u ergens aan denkt). Participants are asked to imagine the situations with their eyes closed. The English scale is reliable and validated.

As the project was carried out in the context of a larger questionnaire study, two other questionnaires were also administered: BMQ-G (Beliefs about Medicines Questionnaire-general, Horne, & Weinman, 1999): the BMQ-G assesses beliefs that medicines are harmful, addictive, poisons which should not be taken continuously and that medicines are overused by doctors. Additionally, a Dutch inventory of attitude to medication was used. Furthermore there were some general questions about participant's health, and an experiment on verbal suggestion, in which a set of six suggestive positively or negatively targeted sentences were presented in a stepwise manner to measure expectations about medicines. These results will not be addressed here as they do not relate to the current research question.

Procedure

Three cohorts of participants: 18-25, 26-45, and 46-65 years were recruited through Qualtrics. The relation between the number of participants within the cohorts reflects the composition of the Dutch population according to the CBS (Centraal Bureau voor de Statistiek) which was not yet completed at the time of the current analysis. For the current proportion of age groups see Table 1.
Participants received a link to the questionnaires through emails, social media or flyers. First, they had to sign their informed consent and after that, they continued with in the questionnaires. The experiment started with a set of questions about demographic data. After the participants had finished the last question, the data were saved in Qualtrics. Duration of the total survey was about 30 to 40 minutes. The order of the questionnaires was randomized.

Analysis

In the current study we will examine the relation between age and imagery ability using correlation analyses, provided by IBM SPSS Statistics 23 software. Because of the ordinal nature of the data (except for age and frequency scores) we will conduct a 1-tailed Spearman rank order correlation after checking for monotonicity. Using Spearman's rho we will test whether there is a relation between age and spontaneous use of visual imagery. The spontaneous, effortless use of imagery scale consists of the sum of the total score of the SUIS and the IMIS frequency score. We expect a positive correlation, so increasing spontaneous imagery with increasing age. We also expect there to be is a positive relation between age and effortful imagery ability. The effortful imagery scale consists of the sum of the VVIQ, the BAIS VC and the VMIQ2 EIK. The Bais VC is the sum score of the BAIS V and C. The VMIQ2 EIK is the sum score of the VMIQ2 E, VMIQ2 I and the VMIQ2 K. Possible confounding factors may be: education level for the correlation between age and spontaneous-and effortful imagery (see Table1). Experience (frequency practicing music) for the correlation between age and BAIS VC, experience (frequency playing video games) for the correlation between the age and VVIQ, experience (frequency practicing sports) for the correlation between age and VMIQ2 EIK, (see Table 1). For these possible confounding factors we will run partial correlation analyses for non-parametric data, using the PARTIAL CORR and NON PAR CORR procedures in SPSS 23, IBM.

To investigate the development over the life-span of the vividness ratings of the specific imagery modalities (visual, auditory, kinesthetic) and their mutual relations, we will also examine the imagery scale scores in an exploratory manner. We will assess the possible effects of age categories on the vividness ratings of visual, auditory and kinesthetic imagery modalities (VVIQ, BAIS V and VMIQ2 K, selected to specifically represent vividness scales) by using three Kruskal-Wallis tests. This because of the ordinal nature of the data, after checking for equal shape and equal variances. Within the three age categories we will examine the relation between the imagery modalities by three correlation matrixes of Spearman rho correlations between visual (VVIQ), auditory vividness (BAIS V) and motor kinesthetic (VMIQ2).

Results

The assumption of monotonicity for Spearman's rho was met, so we used this correlation. Before running the analyses we converted the VVIQ scale and the VMIQ2 E, I and K scales, so that for all the lists 1 indicates no image and 5 indicates a clear image. Thus high scale scores always indicate high vividness.

Age and spontaneous imagery

There was no significant relationship between age and spontaneous imagery, r_s= -.02, $p > .05$. This combined spontaneous or effortless scale consists of the sum of the total score SUIS, tendency to spontaneously use visual imagery, and the frequency score of the IMIS, measuring how often you experience involuntary musical imagery, so-called earworms. For the individual variables of the composed spontaneous use of imagery scale the results were that age was not related to SUIS, r_s =.00, $p > .05$. Thus, increasing age is not related to a greater tendency to use spontaneous imagery. Age was significantly negatively related to frequency IMIS, r_s = -.15, $p < .01$, so with increasing age there is a small decrease of experiencing involuntary musical imagery. Because there was no significant zero order relation between age and the sum score of spontaneous imagery, we did not control for education. There was a significant negative partial correlation between age and the frequency score of the IMIS whilst controlling for education, $r_s = -.13$, $p < .05$, increasing age is associated with decrease of experiencing involuntary musical imagery while controlling for education, indicating that education had virtually no influence on the strength of the relation between the two variables.

Age and effortful imagery vividness

There was no significant relation between age and effortful imagery vividness (total score of VVIQ visual, BAIS VC auditory and VMIQ2 EIK motor), $r_s = .07$, $p > .05$. So with increasing age there is no increase of the vividness of general effortful imagery. However, there were significant correlations between age and the composite parts of effortful imagery: VVIQ, $r_s = .13$, $p < .05$, and BAIS-VC, $r_s = .18$, p < .01. There was no significant correlation between age and VMIQ-EIK, $r_s = -.01$, p > .05. Thus, when age increases the vividness of visual and auditory imagery increases, but there is no increase in the vividness of any type of motor imagery with increasing age.

Table 1

Demographic details for participants: age, education, experience.

	Frequency	Range
Age		18-65
Male	96 (35.2%	
Female	177 (64.8%)	
Education		3-9
1 Non	0	
2 Primary	0	
3 Lower vocational education	6 (2.2%)	
4 High school	5 (1.8%)	
5 Secondary vocational education	38 (13.9%)	
6 Upper secondary education	33 (12.1%)	
7 Higher professional education	77 (28.2%)	
8 Scientific education	110 (40.3%)	
9 Different	4 (1.5%)	
Frequency playing video games last year		1-5
1 never	121 (51.3%)	
2 less then 1 time per month	53 (22.5%)	
3 on average once a month	17 (7.2%)	
4 on average once a week	15 (6.4%)	
5 more then 1 time per week	30 (12.7%)	

Table 1

Demographic details for participants: age, education, experience.

	Frequency	Range
Frequency practicing sports/dance last year		1-5
1 never	22 (9.3%)	
2 less then 1 time per month	26 (11%)	
3 on average once a month	23 (9.7%)	
4 on average once a week	70 (29.7%)	
5 more then 1 time per week	95 (40.3%)	
Frequency playing music or singing last year		1-5
1 never	99 (41.9%)	
2 less then 1 time per month	41 (17.4%)	
3 on average once a month	17 (7.2%)	
4 on average once a week	32 (13.6%)	
5 more then 1 time per week	47 (19.9%)	

Because there was no significant zero order relation between age and effortful imagery, we did not control for education. There was no significant partial correlation between age and visual imagery (VVIQ) whilst controlling for visual experience (playing video games), $r_s = .09$, p > .05, increasing age is not significantly associated with visual imagery. Results of the zero order correlations yield, that there was a significant correlation between age and visual imagery, $r_s = .13$, $p < .05$. The relationship between age and the vividness of visual imagery was changed after controlling for visual experience, indicating that the effect of playing video games explained the relation between age and visual imagery.There was a significant partial correlation between age and auditory imagery (BAIS VC) whilst controlling for auditory experience (playing music or singing), $r_s = .21$, $p < .01$, increasing age is associated with increasing vividness of auditory imagery while controlling for playing music or singing, indicating that this experience had very little influence on the strength of the relation between the two variables.

Auditory imagery – full list

Age was significantly related to the auditory scales: BAIS V, auditory vividness, $r_s = .13$, $p < .05$, and to BAIS C, auditory control, $r_s = .19$, $p < .01$, indicating that when age increases the vividness and changeability of auditory imagery increases.

Motor imagery – full list

Age was not significantly related to VMIQ2 E motor external perspective, $r_s = .04$, $p > .05$, VMIQ2 I, motor internal perspective, $r_s = -.00$, $p > .05$, and to VMIQ2 K, motor kinesthetic perspective, r_s =

-.04, $p > .05$, suggesting that there was no increase in the vividness of the image of watching yourself performing a movement through the eyes of someone else with increasing age, seeing oneself performing a movement from your own perspective with increasing age, or feeling a movement with increasing age.

Age and relations between imagery modalities

We changed the intended distribution over the age categories because of the very unequal numbers of participants from: category one 18-25 years, $n = 66$, category two 26- 45 years, $n = 92$, category three 46-65 years, $n = 111$ to: category one 18-30 years, $n = 102$, category two 31- 49 years, $n = 90$, category three 50-65 years, $n = 77$, resulting in somewhat more similar group sizes. We tested each of the three imagery modalities with an overall Kruskal-Wallis test. VVIQ visual, $H(2) = 3.31$, $p > .05$, BAIS V auditory, $H(2) = 6.10$, $p < .05$ and VMIQ2 K motor kinesthetic, $H(2) = 2.97$, $p > .05$. Only auditory imagery was significantly affected by age categories. Mann-Whitney tests were used to follow up the finding. A Bonferroni correction was applied and so all effects are reported at $p = .0167$. It appeared that vividness of auditory imagery was significantly higher in age category 3 (*Mdn* = 68.50) compared to age category 2 (*Mdn* = 63), ($U = 2574$, $r = 0.18$). However there were no significant differences of auditory imagery vividness between age category 3 and 1 (*Mdn* = 63), ($U = 2806$, abs $r = 0.16$) and age category 1 and 2 (*Mdn* = 63) ($U = 3816$, $r = .01$), indicating that auditory imagery vividness only increases slightly in the oldest group, see Figure 1. Finally, for correlations between modalities by age categories see Table 2, showing that the same pattern, namely a significant correlation between auditory and visual imagery, is shown in every age group.

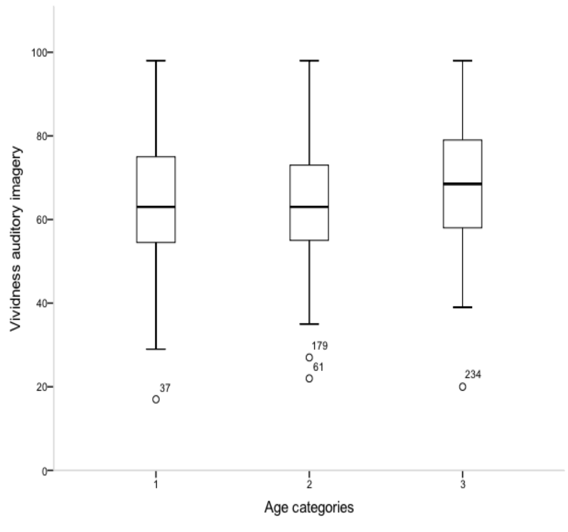

Figure 1. Medians vividness auditory imagery over the age categories

Table 2

Correlations between modalities by age category

	category 1			category 2			category 3		
	visual	auditory	motor	visual	auditory	motor	visual	auditory	motor
visual	1	.53**	-.03	1	.59**	.01	1	.41**	.03
auditory		1	.18		1	-.26		1	.17

Note ** *p* (2-tailed) < *.01.* age cat. 1: 18-30 years, age cat. 2: 31-49 years, age cat 3: 50-65 years

Discussion

In this study a large sample (*n* = 273) of participants varying in age (18-65 years) were examined on their imagery abilities in the visual, auditory and motor modalities by using self-report questionnaires with Likert-scale answer-formats. To our knowledge such a widespread continuous age group has never been examined on different imagery modalities in a single study before. Because of the recent scientific insights on aging and mental imagery we expected that the elderly would perform better on the vividness scores of their imagery than younger people.

Effortless imagery

We differentiated between spontaneous use of imagery and effortful use because of the different applications in daily life, therapy and science. Spontaneous imagery comes to mind without effort, without instructions from the inside or outside world. Effortful imagery needs instructions, this is the kind of imagery used for clinical practice. We found no relation between age and effortless imagery, a combination score of the tendency to use spontaneous imagery in daily life and frequency of involuntary musical imagery. So with increasing age there is no increase in the use of spontaneous imagery. Experiencing a short section of music that comes to mind without effort and with repeats, so-called earworms, and task unrelated thoughts or mind wandering, show a strong correlation (Floridou et al., 2015). Elderly could have less responsibility in society. Consequently, we expected that they might have more task unrelated thoughts and earworms. So we separated the tendency to use spontaneous imagery in daily life and the experience of earworms in their relation to age. The data showed that the tendency to use spontaneous imagery in daily life was the same for old and young participants. However, young people experienced slightly more earworms. Spontaneous imagery of pieces of music seems to occur more in younger people. This could be the consequence of the possibility for hearing music via mobiles with earplugs and the greater role of and attention for music in their life.

Effortful imagery

Our data demonstrate that general effortful imagery is not affected by age. Older people perform after naturalistic imagery instruction as well as younger persons, independent of their education level. Our findings suggest that older people can do as well or even better on visual and auditory imagery. The performance of older people on visual imagery seems to be inconsistent with the research of Piccardi et al. (2015). They found that the performance of the elderly in imagining buildings, but not in imagining common objects was lower than that of younger people. According to Piccardi et al. (2015), a building is used as a navigational stimulus in daily life. The navigational aging hypothesis claims that navigational topographical orientation declines with age. So they explained the age difference in terms of decrease with age. However, there could be other explanations. The common object stimuli, old fashioned sofas could be better known to the elderly then to young people. So part of an alternative explanation of the differences in visual imagery abilities could be long-term perceptual specificity in mental imagery. Long-term perceptual specificity claims that the recollection of an event partially re-activates the same brain regions involved during the original experience (Bucker & Wheeler, (2001), in Pearson & Hollings, 2013). Pearson et al. (2013) reported that the perceptual specificity effects also occur in mental imagery after naturalistic encoding. Consequently, well-known, formerly encountered stimuli are easier to imagine than never seen stimuli. So performance differences between the age groups could stem from different causes than age decline. Potvin et al. (2011) reported that prospective memory problems in traumatic brain injury patients between 18 and 65 years improved after a rehabilitation program based on visual imagery techniques. Visual imagery strengthened the cue action association in ecological situations, so that the participants remembered the intended action in their daily life. Murphy et al. (2015) found that it is possible to engage older adults, aged, between 60-80 years, in cognitive visual imagery training to enhance positive affect about the future. In addition to the above-mentioned studies Blackwell et al. (2012) showed a link between positive future imagery and optimism with participants in the age range 18-65 years. Thus visual mental imagery is a powerful instrument for older people because it is an ability they possess.

The present findings show that vividness and control of auditory imagery both increase with increasing age. After controlling for the effect of playing music or singing the relation between age and the the sum score of auditory vividness and control is still positive. The better performance of the elderly over the younger participants on the control scale of auditory imagery seems in contradiction with the experiments of Dror et al. (1994). They included 64 participants, 32 relatively young subjects (range 18-32 years), and 32 elderly subjects (range 55-71 years) and they measured error rates and response times. In their experiments, the elderly didn't perform well on the transformation aspect of visual mental imagery. Dror et al. (1994) gave the following definition of image transformation: "image transformation is the ability to rotate or otherwise alter an imaged pattern". Our participants altered an auditory image, the participants of Dror et al. (1994) altered a visual image. One of the tasks in this auditory control scale was to imagine the sound of gentle rain and transform this image into a violent thunderstorm. Participants in the experiments of Dror et al. (1994) had to decide whether two shapes where identical, regardless of their orientation, by mentally rotating one shape. The contradiction between our results and the results of Dror et al. (1994) may indicate a difference in the control abilities of visual and auditory imagery for the elderly. Future research could answer this question by investigating visual control and the auditory control within participants of young and old age. Our research took place in a naturalistic, home situation with naturalistic scenes to image. The experiments of Dror et al. (1994) took place in an experimental, laboratory situation with artificial, abstract imagery tasks. So test site could make a difference for older people. Future research with older people should take this in consideration and administer the same imagery tasks at home and in a laboratory. In the definition of Dror et al. (1994) image transformation, rotation and control, the ability to alter an image, the same. It is possibly that these are different aspects of imagery. Our findings, based on a much larger group of participants (n = 273), provide potential for a new division of the imagery aspects which could change the view on the imagery skills of the elderly. However, the present data do not provide enough evidence. Therefore, future studies should examine this possibility. Besides test location, the test content was also different. Boccia, Picardy, Palermo, Nemmi, Sulpizio, Galati & Guariglia (2015) showed different patterns of fMRI activity that reveal different content of visual mental images. The questions of our survey were about scene construction of naturalistic meaningful situations. The tasks of Dror et al. (1994) were artificial and abstract. It could be that older people are better in imaging naturalistic scenes with reliance on long-term memory than in artificial abstract imagery tasks, were working memory acts. Baddeley & Andrade (2000) conclude in their study about working memory and the vividness of imagery that the representations in long-term memory influences the vividness of imagery in two ways: through a direct contribution to the image itself via stored sensory information and because the vividness of an image reflects the amount of information, that can be retrieved in the time available relative to the amount of information sufficient for an image. Older people have lived longer, so they accumulated more sensory information over their lifespan and this could be of influence on their imagery abilities. Future studies should be conducted to examine the performance of different age groups imaging naturalistic scenes and artificial abstract tasks.

This study does not provide evidence for the positive influence of musical training on the relation between age and auditory imagery. This is in contradiction with the conclusions of Aleman, Nieuwenstein, Böcker & de Haan (2000), who found that a musically trained group performed better on musical imagery and non-musical auditory imagery tasks. To our knowledge this is the first study to explore the vividness of auditory imagery over age. Our findings suggest that auditory imagery could be an interesting topic to explore in mental and physical health settings.

For the total motor imagery scale, our study demonstrated equal performance for the older and the younger participants and this was also true for its composite parts. The external perspective showed the only positive, though non-significant, relation. This may thus be the best perspective for use in practical interventions for the elderly, but this is currently inconclusive. The discrepancy between ratings of visual and auditory imagery and motor imagery vividness (see Table 2) could be interpreted by the difficulty understanding what was meant by the three different motor perspectives. This is in line with Robertson et al. (2008) who wrote that there was an ambiguity surrounding the conceptualization of these terms in scientific research. The instructions could be difficult to convert to different forms of vividness ratings in the general population, this might be a matter of concern for future studies. Motor imagery seems to play a different role in the imagery domain than visual or auditory imagery. We will discuss this further below.

Age and imagery modalities

By exploring sensory modalities within age categories our data revealed a very small effect of age group on auditory imagery vividness between middle-aged and older adults, suggesting that older people can perform better on auditory vividness imagery tasks then people between 30 and 50 years. These positive findings on auditory imagery tasks, could be extended to not included other modalities, such as cutaneous (touch), gustatory (taste), olfactory (smell), and organic (feeling or emotion) imagery (Andrade et al., 2014). Mental imagery within different modalities contribute to the etiology, maintenance and treatment of disorders, such as intrusive visual imagery in Health Anxiety (Muse, McManus, Hackmann, Williams & Williams, 2010), intrusive visual, organic and, cutaneous images in the “Hotspots” of Posttraumatic Stress Disorder (Holmes et al., 2005), intrusive visual, auditory and organic images in Major Depression (Patel et al., 2007) and intrusive gustatory, olfactory, organic, auditory and visual images within substance addiction (May, Andrade, Panabokke & Kavanagh, 2004). Older people suffer from the above-mentioned clinical disorders too. Future studies should investigate these other modalities in relation to age, which could yield valuable information, which can lead to better tailored interventions. The relations between visual, auditory and kinesthetic imagery revealed the same pattern within the three age categories (see Table 3). The correlations suggest modality specific and modality independent components to imagery ability. This is in agreement with the reports of Andrade et al. (2014) and Daselaar et al. (2010). Andrade et al. (2014) developed and investigated the factor structure of the Plymouth Sensory Imagery Questionnaire (Psi-Q), a multi-sensory measure of image vividness. Daselaar et al. (2010) compared in their fMRI study brain activity and the subjective imagery vividness ratings of visual- and auditory imagery under matching task conditions. Participants saw a cue word on a screen, thereafter an icon indicating a visual or auditory condition to imagine this word. The researchers identified a modality-independent "core" imagery network, that was related to the Default Mode Network and visual and auditory modality specific areas, related to the association cortices. In the current study, visual and auditory imagery showed medium to large significant correlations (see Table 2). However, kinesthetic imagery did not. Kinesthethic motor imagery does not seem to be a composite of visual image and/or auditory image scene construction. Most research on kinesthetic imagery is about learning movements in sports, such as dance sequences (Cross, Kraemer, Hamilton, Kelley & Grafton, 2008) and basketball shooting (Lam et al., 2009); in rehabilitation, such as improving balance in diabetic patients (Alsubiheen, Petrofsky, Daher, Lohman & Balbas, 2015), and motor learning in stroke patients (Kleynen, Wilson, Jie, teLintel, Hekkert, Goodwin Braun & Susy, 2014). The latter two are particularly important for the elderly. So future studies should be conducted to further explore the nature and basic elements of kinesthetic motor imagery and its relations to other modalities in the elderly.

Conclusion

The current study moderately supports our positive expectation about the relation between age and imagery abilities. No age differences were seen for effortless imagery. In effortful imagery, the elderly appeared to have the same or somewhat better capacities. This could be due to the naturalistic content of the questionnaires. Content and test situation of effortful imagery might be an interesting future research topic in the elderly. Our results suggest that visual imagery and auditory imagery have potential for application in clinical practice with older people. Motor imagery could also have this potential for rehabilitation, as at least it does not decline with age. Our findings have implications for a new vision on the imagery skills of the elderly. Imagery in the other sensory modalities also deserves attention in imagery research, because of the possible insights in intrusive images in mental disorders.

Our research has some limitations. We analyzed the imagery modalities with unequal numbers of participants in the age categories, and a significantly larger proportion of women than men. Furthermore, We also did not include the cutaneous (touch), gustatory (taste), olfactory (smell), and organic (feeling or emotion) imagery modalities. This could have provided us with information about the possibly generating and maintaining factors in different mental disorders, uch as anxiety, depression and PTSD. Furthermore, we didn't investigate spontaneous intrusive imagery in older people. Finally, people who were willing to be part of our research also participated in the research on verbal suggestion and medication use. It appeared that some, mostly young people stopped by filling in the survey after the verbal suggestion questions. For expectation, motivational and time reasons it would have been better to split the surveys. Finally, because we used a sample of 273 participants it is important to keep in mind that correlations reach significance more easily, so we should be careful with the interpretations of the effects of our findings.

The strength of this study is that we combined a large sample (n = 273) of participants, different in age (18-65 years) with three different mental imagery modalities, with an emphasis on the elderly. As far as we know this is the first study of this kind in the imagery field. Our results seem to point in a direction were the elderly are not impaired compared to younger people. So stereotypes about underperforming elderly possibly do not hold in the imagery domain. This cognitive skill could presumably contribute to self-efficiency in the elderly. Self-efficiency is an important building block for optimism and optimism is an important building block for physical and mental health (Blackwell et al., 2012). The current findings thus potentially contribute to more insight in successful aging and non invasive tailored interventions for the elderly.

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