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# PROCESSING METAPHORS IN THE ELDERLY: DOES VALENCE MATTER?

Much evidence from theory and research points towards difficulties in processing metaphors by elderly people. These difficulties are usually associated with working memory and inhibitory control deficits observed in this age group, as these very functions play a crucial part in efficient metaphor processing. However, results of research on understanding metaphorical content by elderly people are inconclusive. The following article reviews studies showing that metaphor processing relies on a set of complex variables, which might explain the inconclusiveness of previous results. Though we acknowledge the role of interindividual factors (differences in cognitive functioning among the elderly), we focus on the properties of the metaphor stimuli themselves, especially those of conventionalization and valence, as they might influence the processing of verbal metaphors by people in older age groups.

*Key words*: metaphors, aging, valence, conventionalization

## Problems with processing metaphorical language: Why is it supposed to occur in advanced age?

### Working memory and inhibitory control deficits in the elderly

People over 60 years of age constitute the most rapidly-expanding population group in the world (currently numbering 700 million, with an estimated increase to 2 billion in 2050, see Antoniou, Gunasekera, & Wong, 2013). Since the 1990s, the average age in Poland has increased by over seven years, and it is anticipated that the changes in social structure will become even more dynamic (Główny Urząd Statystyczny, 2014). Research on cognitive and linguistic functioning of

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the elderly is also being published increasingly frequently. It presents evidence that the number of cognitive deficits observed in elderly people increases with age (see e.g. Craik & Salthouse, 2008; Gawron & Łojek, 2014; Oberauer, 2013). In general, the results show that these age-related cognitive deficits are the most evident in functions associated with the frontal areas of the brain (Gawron & Łojek, 2014; West, 1996), such as working memory, executive functions, and inhibitory control, and are less so in those related to the posterior regions.

The following article will focus in particular on cognitive functions which are important for efficient metaphorical language processing[1] (especially working memory and inhibitory control) and which undergo deterioration in late adulthood. This will serve as basis for a claim that metaphor processing might become impaired in older age groups[2].

Worsening of working memory with age is well-established empirically (e.g. Park et al., 2002; for a review, see e.g. Fedemeier, Kutas, & Schul, 2010). As regards the specific mechanism responsible for the differences in working memory efficiency in adults from different age groups, many authors point towards the elderly experiencing difficulties in inhibiting working memory content unrelated to the task at hand (for a review, see Unsworth, Heitz, & Engle, 2013). These difficulties concern removing from working memory information that is no longer relevant, blocking unrelated information from being stored in working memory, and inhibiting inappropriate behavior (Hasher, Zacks, & May, 1999). Another explanation links working memory deficits with the impairment of the dopaminergic system observed in the elderly (e.g. Braver et al., 2001): Weakening of dopamine's modulating effects would then lead to a worsening of working memory and selective attention (for a review, see West & Bowry, 2013).

Many studies show the effects of working memory and inhibitory control deficits on linguistic functioning among the elderly (e.g. Kemper, 2012; Wingfield & Grossman, 2006), especially on ambiguous content processing. Both general and specific explanations have been proposed in this area as well. An example of a general one focuses on the observed decline of executive functions nonspecific to language, stemming from anatomical reductions within the frontal lobes (Craik & Byrd, 1982; Raz, Rodrigue, & Haacke 2007; reviewed in Baciu et al., 2016), or the (currently being challenged) hypothesis of a general weakening of inhibitory control in the elderly (Hasher & Zacks, 1988). On the other hand, specific explanations assume that the deficits in question

[1] The term "metaphorical language processing" refers to the process of the assignment of meaning to a figurative language expression.

[2] Working memory and inhibitory control deficits are discussed in more detail as functions especially important in the successful interpretation of metaphors (cf. Kintsch's, 2000, 2001, predication model, and its empirical verification), but other cognitive functions (e.g. sustained attention or attention switch) may play an important role as well. The article discusses neither the deterioration of general health nor sensory deficits in the elderly although these problems may also negatively impact language functions. Understanding figurative language is an important component of communicative competence. Deficits in this area may result in older adults' problems in everyday communication.

might be closely related to language skills themselves, or even to particular stages of language production. One such explanation posits that older adults begin preparing responses earlier and with more effort than do younger people, as they are afraid of making a mistake (for a review of different aspects of language production in the elderly, see Griffin & Spieler, 2006). Elderly people begin planning their utterances much earlier in order to maintain fluent speech, which might additionally burden working memory resources.

Another proposed link between working memory deficits and specific aspects of language processing in the elderly is that the impairment of working memory affects syntax processing which, in turn, makes utterances produced by older adults less informative (see Ferguson, Spencer, Craig, & Colyvas, 2014). In particular, older people split large syntactic units into smaller ones (in a process referred to as *chunking*) more often than do young people (cf. the results of Payne et al., 2014; see Stine-Morrow & Miller, 2009, for a discussion). In a sample of 100 young and 100 older (63-88 years of age) adults, Kemper and Sumner (2001) compared a range of linguistic markers basing on short verbal descriptions with results from tests measuring cognitive functioning. Their analysis revealed a covariance (in both age groups) of working memory performance (digits forward and backward) with the type-token ratio (designed to be a measure of vocabulary size) and D-Level (a measure of sentence clausal complexity). The study by Juncos-Rabadán, Pereiro, and Rodríguez (2005) also points towards a connection between lowered working memory efficiency and a deficit in narrative processing (the elderly communicate the same amount of content as younger people, though using more words).

Deficits in inhibitory control and working memory also influence verbal metaphor processing in a specific way, which can be inferred on the basis of Kintsch's (2000, 2001) predication model, described below.

## Working memory and inhibitory control in metaphor processing: Models

Among the theoretical models and empirical research enabling conclusions about how working memory influences the processing of metaphorical content, the most relevant conceptualization of working memory seems to be the one proposed by Unsworth et al. (2013, p. 32). Referring to Cowan's (1988, 1995) arguments, this model assumes executive attention to be a crucial component of working memory. The role of executive attention involves maintaining or inhibiting the activation of long-term memory units and goals, monitoring and resolving conflicts, and allocating attentional resources. Unsworth et al. (2013) predict that individual differences in working memory should become pronounced to the greatest degree in situations where attention must be directed towards a primary task while inhibiting potential internal and external distractors is simultaneously required. According to Kintsch's (2000, 2001) model, interpreting a metaphor, especially an unconventional one, is a perfect example of such a task.

Kintsch's (2000, 2001) predication model is a computational model which generates possible metaphor interpretations based on a complex interaction between the verbal meanings of the topic and of the vehicle. The model anticipates which qualities of the vehicle will be selected, and which ones will be ignored as unrelated (e.g. motion sickness in the well-known metaphor of LOVE IS A JOURNEY) in the process of metaphor understanding. Comprehension of metaphorical expressions is conceptualized here as a process of activation spreading in a self-inhibiting semantic network. Meanings strongly related to the vehicle but not to the topic are inhibited by those terms in the vehicle's neighborhood that can be assigned to the argument. The predication model involves two components. The first one (the LSA component) represents word meanings, while the second (the CI component) uses these representations to arrive at a context-appropriate interpretation of a phrase with the predicate structure of "ARGUMENT is a PREDICATE" (by selecting these qualities of the predicate which are appropriate for the argument and inhibiting the ones which are not). The CI first activates the closest meanings in the semantic network. Then, the vector representing the predicate is modified so that a context-appropriate meaning can be established.

Kintsch's model predicts that people with working memory and inhibitory control deficits might not have sufficient resources to activate an appropriately complex semantic network, and that they might cope less well with inhibiting distinctive but irrelevant qualities of the predicate. As a result, they may provide interpretations of metaphorical statements more slowly, and these interpretations might be of poorer quality.

Another model that highlights the role of working memory and inhibition processes in metaphor processing is Glucksberg's class-inclusion model (Glucksberg, 2001, 2003; Glucksberg & Keysar, 1990). Here, the metaphor interpretation process is described as the activation of a context-appropriate, dominant ad hoc category that enables the metaphorical meaning to be interpreted correctly (e.g. the category of "actions that make the objects similar" in the case of the metaphor *school education is trimming the hedge*). Similarly to Kintsch's model, emphasis is placed on efficient inhibition of metaphorically irrelevant but distinctive qualities of the metaphor vehicle (e.g. garden activities) and highlighting the qualities relevant for the dominant interpretive category (uniform look and functioning).

**Working memory and inhibitory control in metaphor processing: Results**

The significant role of working memory and inhibition mechanisms in metaphor processing has been confirmed by many empirical studies. For example, Chiappe and Chiappe (2007) showed that regardless of a person's level of vocabulary and readership, working memory (measured by performance in digit span reverse tasks) and inhibitory control (measured by performance in the Stroop task) affect the understanding of metaphorical sentences (e.g. *Wisdom is an ocean*, *Young girls are televisions*). These results are interpreted as confirming the assumption that working memory and inhibitory control are essential for inhibiting those qualities of the vehicle which are very salient, but which disrupt the metaphorical interpretation.

Results testifying to the role of working memory and inhibitory control in understanding metaphorical content were also obtained by Blasko and Trich (1997; cited in Blasko, 1999), Monetta and Pell (2007), and Gernsbacher, Keysar, Robertson, and Werner (2001).

However, some researchers posit that it is short-term memory (understood as the ability to temporarily store information in the hypothetical space within one's mind), not working memory, that is crucial for verbal metaphor understanding. At the same time, short-term memory is often cited as another ability decreasing with age (e.g. elderly adults perform less well than younger people do in tasks requiring serial stimulus recall from the short-term memory; Maylor, Schlaghecken, & Watson, 2013). Iskandar and Baird (2014) studied the role of short-term memory, working memory, and divided attention in understanding sentence metaphors with the structure *X is (a) Y*. Their results show that short-term memory span (measured by performance in a sentence repetition task) predicts producing correct (abstract complete) metaphor interpretations to a greater degree than does working memory and divided attention. The authors, similarly to Chiappe and Chiappe (2007), treat their results as confirming the validity of computational models (e.g. Kintsch's predication model), as they claim that metaphor interpretation requires storing the metaphorical phrase in one's memory long enough to allow for semantic comparisons.

## Metaphor processing in the elderly and the models of cognitive aging

The high probability of deficits in figurative content processing among the elderly can be inferred from the working memory and inhibitory control impairments observed in this age group, as these functions play a key role in efficient metaphor understanding, as has been reviewed above. Another line of evidence is related to neuropsychological models of aging, especially the frontal and the right hemisphere hypotheses (reviewed in Gawron & Łojek, 2014).

The frontal hypothesis of aging assumes that the physiological processes of aging are the most intense in the cortical and subcortical frontal areas of the brain (West, 1996). The effects of aging should, then, be visible earlier in cortical than in noncortical cognitive functions, such as working memory, executive functions, and inhibitory control (for a review, see West & Bowry, 2013). These functions – as has been mentioned above – are simultaneously closely related to processing figurative content, especially of an unconventional nature.

The right hemisphere hypothesis – stating that the right hemisphere ages quicker than the left – claims that typical age-related deficits are similar to those observed after right hemisphere injuries (for a review, see Gawron i Łojek, 2014). These deficits include spatio-visual processes, attention, strategy-driven coding and recall, as well as metaphor understanding (cf. the study by Łojek, 2007, employing the Written Metaphor and Explaining Written Metaphor subtests of the Right Hemisphere Language Battery, RHLB-PL). For years, the right hemisphere has traditionally been linked to nonliteral language processing (see e.g. the right hemisphere theory of metaphor processing; Winner & Gardner, 1977). The simplicity of this connection is currently being questioned (see e.g. studies by Rapp, Leube, Erb, Grodd, & Kircher, 2004, 2007; Shibata, Abe, Terao, & Miyamoto, 2007), but the majority of the authors do not disprove the right hemisphere's role in processing metaphorical content, especially of unconventional character (see review in Bartczak & Bokus, 2013).

In spite of robust theoretical evidence for metaphorical content processing deficits in the elderly, empirical results remain inconsistent. Many studies conducted to date on metaphor comprehension by the elderly indicate the existence of deficits in this area (e.g. Łojek, 2007; Monetta & Pell, 2007; Uekermann, Thoma, & Daum, 2008). For example, in the study by Łojek (2007) concerning the Polish adaptation of the Right Hemisphere Language Battery, healthy persons 66-84 years of age achieved lower results than persons aged 23-65 years in the picture metaphor explanation subtest, with the mistakes involving either literal explanations or explanations which were abstract but inadequate (see review in Gawron & Łojek, 2014). On the other hand, many studies do not indicate that problems with understanding figurative content increase with age (e.g. Gawron, 2006; Łuczywek & Kądzielawa, 2005; Ulatowska, Chapman, Highley, & Prince, 1998; Williams, 2006; reviewed e.g. in Gawron & Łojek, 2014), and some suggest that such problems do not emerge until very advanced old age (Łuczywek & Kądzielawa, 2005). The following part of this article will present possible explanations of the inconsistency in the results pictured above.

## Is metaphor processing disturbed or undisturbed in the elderly? Possible explanation of the inconsistency in research results

The inconsistency in research results on metaphorical content processing by the elderly can be explained both in reference to the specifics of this age group as well as to the specifics of metaphors themselves. The first category includes, among others, a lack of precision in demarcating the beginning and the stages of old age, large interindividual variance in cognitive functioning among the elderly, and the use of neurocompensatory strategies which might attenuate the differences in behavioral test results between older and younger people, despite the fact that the elderly will have invested more cognitive effort into those tasks. Explanations related to the character of metaphors themselves involve difficulties in establishing the scope of the cognitive-linguistic phenomenon of the metaphor, as well as select qualities of metaphors, especially conventionalization and valence. This article will present explanations related to the characteristics of the older age group briefly; greater emphasis will be placed on discussing the qualities of metaphor stimuli – conventionalization and valence – which might influence metaphor processing by the elderly. Valence seems especially deserving of closer attention, as only a few of the studies on figurative stimuli processing published so far includes this variable despite the existence of considerable evidence for its influence on information processing by elderly people.

**Processing metaphors by older adults: By who exactly?**

The inconsistency observed in research results published thus far can be explained by reference to the age criterion. Who exactly is an "older person?"

Psychological literature is divided on the subject of the criteria and periodization of older age (Steuden, 2011, pp. 20-21). The Central Statistical Office of Poland takes 60-65 years of age as the beginning of older age, similarly to the WHO (Steuden, 2011). Different divisions of older age into periods can also be found: The majority of authors agree that – taking into account the general health and cognitive functioning of the elderly – several qualitatively different stages of older age can be distinguished (e.g. the "younger elderly": 60-75 years old, and the "older elderly": from 75 years of age, as discussed in Steuden, 2011; or the various three-stage conceptions of older age, such as 60-70, 70-80, 80 years and more; or 60-65, 65-85, above 85 years; cf. Birch & Malim, 1999, cited in Steuden, 2011).

Meanwhile, research on the cognitive and linguistic functioning of the elderly employs participants of varying age, with the age span of the studied groups being wide as well. The most commonly included age group comprises people from 60 to 80 years of age (cf. 60-80 years in Valente & Laganaro, 2015; 60-81 years in Payne et al., 2014; 60-78 years in Grieder et al., 2012; 66-84 years in Łojek, 2007, etc.), though studies including much older (e.g. 78-92 years in Snowdon et al., 2000; cited in Antoniou, Gunasekera, & Wonga, 2013; cf. also the studies on centenarians by Łuczywek & Kądzielawa, 2005) as well as much younger adults (e.g. 41-67 years in a study by Manan, Franz, Yusoff, & Mukari, 2013) have also been published. All of these studies speak of *older people* and *aging* despite the fact that the level of cognitive functioning in each consecutive decade of life might be completely different. When discussing evidence of metaphor processing deficits in the elderly, it is difficult to point to a specific period in which these problems are to begin developing.

## Interindividual differences in older adults' cognitive efficiency

Cognitive functioning in late adulthood varies greatly from person to person. A review by Gawron and Łojek (2014) shows clearly that aging of the brain takes a varied course between individuals and is a function of many biological, psychological, and social factors. A small subset of people continue to function cognitively on a level comparable to that of young age, or maintain their level of functioning for a long time without changes (so-called *successful aging*). The majority of the elderly, however, experience a decrease in cognitive functioning, though not to such an extent as to severely inhibit their daily functioning (*normal aging*, review in Gawron & Łojek, 2014). As people age, the interindividual differences in cognitive functioning become more pronounced. Gawron and Łojek (2014) provide evidence that neuropsychological profiles of people in their 8th and 9th decade of life – relatively healthy, of a similar age and education, not suffering from dementia or depression – are very varied.

This variance in cognitive functioning among the elderly is usually explained with reference to the so-called *cognitive reserve*. Two models of cognitive reserve in the elderly can be found in the literature (cf. review in Valenzuela & Sachdev, 2006). The first one states that some hardwired anatomical and physiological characteristics of the brain (e.g. slightly larger size, greater neuron density in the frontal, parietal, and temporal cortex) serve as a threshold against degenerative processes (e.g. Satz, 1993). The second model posits that the cognitive reserve might be a function of the brain's greater efficiency in making use of available resources and employing processing strategies. What follows is that the functioning of one's brain in older age can, to some extent, be improved through individual effort. The literature provides plentiful evidence of the positive link between cognitive, physical, and social activity and the level of cognitive functioning in older age (review in Antoninou et al., 2013).

Another factor that could possibly explain the differences in cognitive functioning between people in late adulthood is the presence of diseases more frequent among that age group. For example, some research shows that hypertension can inhibit cognitive and linguistic functioning (e.g. Reitz et al., 2007, discussed in Carvalho, Barreto, Guerra, & Côrtes Gama, 2009). There is evidence of subcortical ischaemic vascular dementia causing difficulties in semantic processing (Vuorinen et al., 2000, discussed in Carvalho et al., 2009) and deficits in working memory and executive functions (review in Gawron & Łojek, 2014) as well.

Older adults show interindividual differences in cognitive functioning, and these differences become more pronounced with age. This constitutes one of the reasons for the inconsistent results of research on cognitive functioning (and metaphor processing in particular) in this age group: Different studies control for different confounding factors.

**Neurocompensatory mechanisms in older adults**

The aforementioned inconsistency could also be explained by neurocompensatory mechanisms observed in older people. There is a lot of evidence that aging involves changes not only in the structural but also in the functional organization of the brain: Even if performance remains at the same level, neuroimaging results often suggest different activation patterns in the elderly than in young people, especially in regions of the brain not typically related to the performance of a given task (see e.g. Brown et al., 2005).

The literature describes two main phenomena linked to preserving cognitive skills in the elderly. One of them is the Hemispheric Reduction in Older Adults (HAROLD; Cabeza, 2002). HAROLD involves decreasing hemispheric asymmetry with age: Left hemisphere activation in the frontal lobe cortex in young people changes to bilateral frontal activation in the elderly. The changes actually take place in the frontal lobe cortex, as this is an area particularly susceptible to age-related reorganization (Raz, 2000). The frontal cortex (especially the prefrontal regions) is also responsible for cognitive functions important for metaphor understanding, such as working memory and attention, as well as for a number of language functions, for example, word concept monitoring (reviewed in Kahlaoui et al., 2012).

The other phenomenon, posterior-anterior shift in aging (PASA; Davis, Dennis, Daselaar, Fleck, & Cabeza, 2008; Grady et al., 1994), is related to reduced occipital activity combined with greater frontal lobe activity observed in the elderly, and is also interpreted as a compensatory mechanism (Stern, 2009). Based on HAROLD and PASA, Park and Reuter-Lorenz (2009) proposed an integrative view of the aging mind, the scaffolding theory of aging and cognition (STAC). In this concept, neurofunctional reorganization already begins in early adulthood, serving as a "scaffold" that maintains cognitive functions at an unchanged or only slightly lowered level. First, the neuronal reserve is used (expressed mainly in interhemispheric reorganization), and then neuronal compensation (reorganization within the same hemisphere) occurs.

Changes in functional organization have been confirmed by numerous empirical studies. In studies on language, such evidence was obtained, for example, in an fMRI study by Baciu et al. (2016) on the effect of aging on word retrieval and generation. Although the performance in the naming task was similar in the two age groups, neuroimaging results were different. In younger people ($M_{age}$ = 42.6, range 30-59), an activation of a wide network involving the frontal, parietal, lateral and medial temporal, occipital, and limbic regions was observed. In the elderly ($M_{age}$ = 72.2, rage 60-84), right hemisphere activations also occurred, in particular, in the right hippocampus and the inferior parietal lobule. Contemporary studies (e.g. Hamamé, Alario, Llorens, Liégeois-Chauvel, & Trébuchon-Da Fonseca, 2014) employing picture-naming tasks show that the hippocampus activates during the search for associations between object identification and its verbal label, though the literature points towards the left hippocampus usually being activated. The right hippocampus activation has been interpreted by Baciu et al. as an effect of the right hemisphere shift in late adulthood.

Results confirming the neurocompensatory hypothesis have also been achieved by Cho et al. (2012). Participants from three age groups (10-20, 30-40, 50-60 years of age) carried out a category decision task. fMRI results have shown that activations in the classical language processing areas (viz., Broca's and Wernicke's areas) did not differ substantially between the studied age groups. However, significant differences occurred in the areas of the brain not primarily associated with language processing, such as the hippocampus, middle frontal gyrus, ventromedial frontal cortex, medial superior parietal cortex, and posterior cingulate cortex. The older the group, the lesser lateralization of the inferior frontal gyrus and the middle frontal gyrus activation was observed (young participants exhibited left hemisphere activation). Compared to the youngest age group, greater bilateral activation in the superior frontal gyrus, thalamus, cerebellum, and hippocampus was observed in the elderly.

Meunier, Stamatakis, and Tyler (2014) have also achieved interesting results. They studied the correlation between the brain areas which are activated during listening to syntactically ambiguous sentences and age, neuroanatomical variations (global gray matter density, GMD), and behavioral data. On the basis of a comprehensive review of the literature, the authors have constructed a template of brain areas involved in language processing. The template was comprised of 16 anatomical areas, including the bilateral regions responsible for language understanding, such as the inferior frontal gyrus (IFG), superior (STG) and middle temporal gyri (MTG), angular gyrus, supramarginal gyrus, and the inferior parietal lobule. Next, differences in brain area activation observable in people from different age groups were compared. Syntactic processing was revealed to have been heavily left-lateralized among the younger age groups (left MTF, left IFG, and the connectivity between them). As reduction in local GMD (observed more commonly in older people) progressed, connectivity increased in the right hemisphere and decreased in the left. The reduction in GMD was also tied to a general increase in functional connectivity of the whole language template, but also with decreased connectivity in the functional system responsible for syntax processing. What is especially interesting is that despite the changes in brain activity, the behavioral results did not differ significantly across the age groups. Meunier et al. interpret these results as validating the neurocompensatory theories and those approaches which stress caution in interpreting behavioral data only when comparing different age groups.

To my best knowledge, no studies of brain correlates of metaphor interpretation by the elderly, taking into account both the valence and conventionalization of used stimuli, have been conducted. Naturally, this points to the necessity of carrying out such research in the future. Based on the existing literature, however, it can be anticipated that neurocompensatory mechanisms may cause potential problems with interpreting the results of studies on processing metaphorical content by the elderly. Although the performance may remain at an unchanged level, neuroimaging results may be significantly different in younger and older adults. The differences in brain activation can be evidence of, for example, greater effort invested into the tasks by the elderly. If only behavioral results are to be considered, however, it is likely that their analyses will not reveal intergroup differences.

## Problems with compering results of younger and older results

When interpreting the results of studies involving elderly people, one has to take into account problems with comparing the performance of older and younger people (cf. McKoon & Ratcliff, 2013). Of course, this is not exclusive to studies on metaphor processing only, but rather concerns comparisons of cognitive functioning of people in different age groups in general. However, it can prove to be especially important when examining metaphor understanding in particular.

Many authors underscore the fact that we usually have to contend with different baseline levels of performance in the elderly than in younger people. For example, the overall response time (RT) is usually longer (cf. the cognitive slowing hypothesis regarding the elderly, e.g. Cerella, 1985; Salthouse, 1985, 1996), whereas accuracy – depending on the task – can be higher or lower. Subjects in late adulthood are usually more afraid to make mistakes than younger subjects, even if this strategy slows down task performance. The two aforementioned problems lead to the third one: that of scaling (cf. McKoon & Ratcliff, 2013).

Needless to say, all these problems can also occur in studies of metaphor processing in the elderly. One solution is to include a method intended for analyzing the results of people of extremely different ages. An example is the diffusion model (Ratcliff, 1978; Ratcliff & McKoon, 2008). The diffusion model was designed to explain all aspects of data at the level of individual subjects: accuracy, mean correct and mean error RTs, the shapes and locations of RT distributions, and the relative speed of correct and incorrect responses (McKoon & Ratcliff, 2013), and it can be used in studies on people in both early and late adulthood.

The diffusion model was used, for example, in a study on drawing predictive inferences by younger and older adults (McKoon & Ratcliff, 2013). The participants were asked to read a sentence and decide it if included a word explicitly expressing an inference. The results showed that RTs were longer in older adults but the accuracy was not significantly worse. The diffusion model managed to reconcile the seemingly inconsistent results, mapping the two variables onto a single one underlining the decision-making process. It also resolved the problem of scaling. The analyses demonstrated that longer RTs in the elderly were caused by differently-set decisional criteria: Older adults were more afraid to commit an error.

Comparing the results of people in widely disparate age groups involved a greater number of problems with analyzing the obtained data, and the multifaceted character of how older people engage in task completion make drawing unambiguous conclusions difficult. Depending on the employed method of statistical analysis and the amount of factors controlled for, it is possible to achieve differing results even in similar tasks.

## Controlling selected qualities of metaphorical stimuli

The lack of a precisely defined age span constituting old age, differences in cognitive functioning among the elderly, and the possibility of drawing misguided conclusions based on behavioral data only do not exhaust the probable explanations of the inconsistencies seen thus far in research results on metaphor processing. Another line of reasoning concerns the nature of the verbal metaphor itself. What exactly is a *metaphor*? Which of its qualities can affect the manner and the difficulty of its processing?

Various studies have employed various stimuli, all of them being subsumed under the shared label of *metaphor*. For example, many metaphor studies carried out thus far have focused on processing the semantic relationships (of a metaphorical nature, e.g. *deep–wise*, compared to nonmetaphorical, e.g. *rehearsal–training*) between single words (cf. the comments in Schmidt, DeBuse, & Seger, 2007). Other studies focused not on word pairs, but on larger units of language: phrases and sentences. Processing of single word pairs can, however, engage different cognitive functions than processing larger units of meaning (cf. the discussion in Rapp et al., 2004, 2007). However still, even employing metaphorical sentences only can result in a wide variety of stimuli. The metaphorical structure most commonly used in contemporary research is *An A is a B* (e.g. Rapp et al., 2004, 2007; Shibata et al., 2007), but it is possible to use other structures based on other theoretical conceptions of metaphor (e.g. *X seems Y*, Dobrzyńska, 1994; *X is like Y in terms of Z*, End, 1986; *When I imagine X, I see Y*, Stępnik, 1988; or *One could say that X is not X, but Y*, Wierzbicka, 1971; cf. discussion in Bartczak & Bokus, 2013).

Almost all researchers of metaphor have commented on the ambiguity of this term. *Metaphor* has been understood either as a linguistic or a cognitive phenomenon (Lakoff & Johnson, 1980); as a process of comparing and finding similarities between concepts not expressed literally, as the process of using the rule of analogy (e.g. Gentner, Bowdle, Wolff, & Boronat 2001), or the result of a process of class inclusion (cf. the class-inclusion model, see e.g. Glucksberg & Keysar, 1990; Glucksberg, 2001, 2003). Some authors posit that metaphor is a phenomenon describing the way in which the brain operates and that the construction of *X is (a) Y* should thus be treated as an instruction to link one connectionist network with another (c.f. the neuropsychological theories of metaphor, e.g. Schnitzer & Pedreira, 2005).

In her monograph on metaphor, Dobrzyńska (2012, p. 133) writes that "metaphor has become a popular, often-used term, though it is used with different meanings, regarding different phenomena." This ambiguity of meaning can also be perceived in contemporary research on metaphorical language processing (review e.g. in Bartczak & Bokus, 2013; Dryll & Bokus, 2016), and it can also cause inconsistencies in research results.

The remaining part of this article will present two qualities of metaphorical stimuli which importantly influence metaphor processing: conventionalization and valence. The role of conventionalization seems to be undisputable and has found considerable evidence in research. Valence, on the other hand, seems to have been studied less thoroughly, though many theoretical and empirical clues point towards the need to control the affective qualities of stimuli employed in research on language processing.

## Influence of conventionalization on metaphor processing

Conventionalization (i.e. familiarity and prototypicality of a given language unit) is another variable with a possible significant impact on metaphorical content processing. Many theoretical models and studies on metaphor comprehension indicate that metaphors appearing frequently in speech are processed differently than unconventional ones. For example, the graded salience hypothesis (Giora, 1997, 2002) claims that it is not the metaphorical character of an expression but its saliency which determines how easy (or difficult) it is to process. According to Giora (1997), only new metaphors are processed differently than literal language: While in the case of conventional metaphors the figurative meaning is processed before the literal, with new metaphors, activating the literal meaning before the figurative is more likely (review e.g. in Iskandar & Baird, 2014).

An important clue pointing towards the importance of conventionalization for verbal metaphor processing comes from studies on brain correlates of figurative language processing. The theory which has caused the most lively discussions in the literature has been the right hemisphere theory of metaphor processing (Winner & Gardner, 1977, reviewed in Rapp et al., 2007). Its main argument states that figurative meanings chiefly engage the right hemisphere, which, in turn, plays an important role in nonliteral language processing (metaphor, humor, irony, sarcasm, proverbs). Despite many studies initially confirming these assumptions (e.g. Bottini et al., 1994; for a review, see Kacinik & Chiarello, 2007), an increasing number of recent publications undermines the simplicity of the posited link between right hemisphere activation and metaphorical language processing. For example, Shibata et al. (2007) have shown in an fMRI study that both hemispheres become activated during metaphorical stimuli processing, with the left hemisphere showing even greater activation than the right one, while, according to the results of Rapp et al. (2004, 2007, using fMRI), metaphorical sentence processing is related chiefly to the activation of the left, rather than the right hemisphere: Reading metaphorical content (compared to literal) was especially linked to activation in the left inferior frontal cortex (BA 45/47) and the left temporal cortex.

These research results seem to prove that differing brain activation patterns are the precisely the effect of conventionalization: Processing familiar and well-established metaphors is mainly the domain of the left hemisphere, whereas the right hemisphere is more responsible for processing unfamiliar and unusual ones. This can be explained with reference to, for example, the coarse coding theory (Beeman, 1998; Jung-Beeman, 2005). It claims that both hemispheres are involved in the process of semantic processing, but in a different manner. After encountering a language stimulus, the left hemisphere engages in fine semantic coding in a narrow semantic field, whereas the right hemisphere is responsible for activating a wide variety of semantic traits, comprised of many different meanings and further associations (coarse semantic coding). A study by Kacinik and Christine (2007) on hemispherical asymmetry in metaphor processing reaches similar conclusions. Based on the authors' results, it can be anticipated that both hemispheres take part in metaphor processing, but that they do so via different mechanisms. The left hemisphere uses the context of a given sentence to select and integrate contextually significant meanings (both literal and nonliteral), while the right hemisphere, less focused on the sentence context, is responsible for generating alternative interpretations. In a situation of semantic ambiguity (often present in the case of new, original metaphors), it is more beneficial to activate a wider array of semantic traits so that meaning can be assigned in a more precise manner.

The role of conventionalization in metaphor processing has been confirmed in many empirical studies. For example, Blasko et al. have pointed towards conventionalization as one of the factors influencing the speed of metaphor processing: In a study employing priming, well-known metaphors prompted a near-instant activation of the metaphorical meaning (see Blasko & Connine, 1993) while an eye-tracker study has shown that participants read conventionalized metaphors faster than they did original ones (see Blasko & Briihl, cited in Blasko, 1999). Another argument comes from experiments carried out using the divided visual field technique. For example, Schmidt et al. (2007) have manipulated the degree of familiarity of a given metaphor by separating the stimuli presented to the participants into four categories on the basis of conventionalization. Their results confirm that activation patters observed during semantic processing are better explained with reference to the degree of familiarity/conventionalization, rather than to a direct opposition of metaphorical-literal (familiar metaphors were processed more quickly by the left hemisphere, while original and uncommon ones – by the right hemisphere). Mashal, Faust, Hendler, and Jung-Beeman (2007) in an fMRI study have achieved similar results. The authors have analyzed neuronal networks related to the processing of literal, meaningless, conventional metaphorical, and new metaphorical word pairs: The participants were asked to read the word pair and decide which relation exists between the words. Based on the observed patterns of brain area activation, the authors concluded that the degree of a given phrase's conventionalization was significantly more important for differentiating between those patterns than was the literal-metaphorical distinction. Processing new metaphors, in contrast to conventionalized ones, was tied to a greater activation in the right posterior superior temporal sulcus, right inferior frontal gyrus, and in the left middle frontal gyrus. These results confirm the selective right hemisphere involvement in the processing of novel, nonsalient metaphorical meanings.

Thus, the role conventionalization plays in nonliteral content processing is well-documented empirically. The aspect of conventionalization in research on metaphors turned out to be so significant that some researchers have even wondered if familiar, conventional metaphors should be treated as nonliteral expressions at all. The inconsistency in the results of studies on metaphor processing by older adults could have thus been caused by conventionalization of the stimulus material being controlled to various degrees between individual studies. In elderly people, the differences in processing conventional and unconventional metaphors could be additionally augmented by the deteriorating functioning of the right hemisphere (cf. the right hemisphere aging theory), thought to deal with processing of new, seldom-encountered metaphorical associations. This supposition seems to find confirmation in empirical research results. For example, older people (similarly to people suffering from Alzheimer's disease) make mistakes concerning unconventional metaphors even though they have no trouble interpreting popular ones (Gawron, 2008; Papagno, 2001).

## Influence of valence on metaphor processing

Valence (positive or negative axiological meaning) is a variable which can significantly impact metaphor processing in the elderly. Not controlling for valence can thus constitute another explanation for the inconsistent findings in this field. Though very interesting, this line of inquiry has been empirically pursued to only a slight degree: To my best knowledge, no research published so far has examined the influence of positive and negative meaning of a metaphor on the ease of its processing in Polish-speaking groups.

Valence is a variable seldom considered in research on metaphorical content processing (cf. discussion in Bartczak & Bokus, 2013). Meanwhile, a study by Bromberek-Dyzman (2011) on the processing of irony showed that this variable has a greater impact on ease of processing than the ironic nature of the communication. The results indicate that processing is the quickest in the case of positive literal statements and the slowest for negative literal statements. How valence influences processing of stimuli is an issue of growing interest in neuroimaging studies. Contemporary research has confirmed the affective prediction hypothesis (Barrett & Bar, 2009) according to which identification of the emotional value of a stimulus is concurrent with its recognition, and the brain continually predicts the valence and importance of arriving stimuli, without the involvement of consciousness. It was shown that the valence of a stimulus affects the style, speed, and intensity of its processing: Negative stimuli are processed noticeably slower than positive ones, regardless of their modality (negativity bias vs. positivity offset), and different anatomical areas are involved in their processing than the ones activated in response to a positive stimulus. Bromberek-Dyzman's study confirms the assumptions resulting from the affective prediction hypothesis in relation to nonliteral language processing.

Although people in late adulthood were not included in Bromberek-Dyzman's study, it is highly probable that valence will influence metaphorical language processing in the older adult group as well. First, it seems that the elderly react to affectively charged stimuli in a different manner than do younger people – among others, they exhibit a tendency to ignore or react less intensely to negative stimuli. This phenomenon is referred to as the *paradox of emotional well-being in aging* or the *emotion paradox* (for a comprehensive review on age-related differences in emotion processing and their neuropsychological foundations, see Mather, 2012). This phenomenon is not limited to nonliteral language processing; it was also studied in relation to stimuli of different modalities and belonging to different areas of human functioning, though it is observed in language processing as well.

Research on the emotion paradox has been inspired by the observation that elderly people, despite their declining health, many losses and negative experiences in their private lives, experience negative emotional states for shorter durations than do younger people, and they maintain positive affect for longer (Carstensen, Pasupathi, & Nesselroade, 2000; Hay & Diehl, 2011). Many varying explanations of this phenomenon have been advanced, concerning, among others, patterns of brain activity and emotional control strategies, as well as the manner in which the elderly process affectively charged stimuli.

One of the explanations claims that areas of the brain responsible for emotion processing (in particular the ventromedial prefrontal brain regions) are subject to lesser structural damage with age than is the dorsal and lateral prefrontal cortex (PFC; reviewed in Mather, 2012). The ventromedial PFC, which plays an important part in emotion regulation, develops earlier in childhood than other regions and it maintains cortical thickness throughout the lifespan (Fjell et al., 2009; Shaw et al., 2008), whereas the lateral and superior regions of the PFC lose their thickness to a substantial degree. These results – as Mather (2012) points out – suggest that parts of the neural circuitry essential for emotion regulation maintain their functioning in older age while other functions decline.

Another model of the emotional paradox in aging states that older adults use different emotion regulation strategies than do younger adults (cf. Mather, 2012). In particular, older adults prefer strategies centered around ignoring those stimuli which might invoke negative emotion and they engage in their processing less eagerly. For example, in a study where neutral and negative stimuli were simultaneously presented to older adults, they exhibited a greater tendency than younger people towards looking away from the negatively charged pictures (Knight et al., 2007; Mather & Carstensen, 2003). People in late adulthood also seem to be more effective than younger adults in avoiding negative distraction. These results are interesting, considering the overall greater susceptibility of the elderly towards distractors: This susceptibility does not apply to distractors of an emotional nature – the elderly seem to manage negatively charged distractors even more efficiently than do younger people (e.g. see the studies employing the emotional Stroop task; LaMonica, Keefe, Harvey, Gold, & Goldberg, 2010). This is confirmed by neuroimaging studies (see e.g. the fMRI study of interior frontal engagement in managing emotional interference by Samanez-Larkin, Robertson, Mikels, Carstensen, & Gotlib, 2009).

Much evidence suggests that downregulating negative affect may be a default mode for older adults. Older adults shift their priorities more towards emotion regulation and less towards other goals (e.g. information seeking). This is explained, e.g. by the socioemotional selectivity theory (Carstensen, Fung, & Charles, 2003; discussed in Steuden, 2011), which states that elderly people prefer less numerous, but more emotionally satisfying social relationships and that they begin to perceive time in a different manner. In young age, time is perceived as unlimited, and the most important life goals are oriented towards the future, whereas during maturity, people start to perceive time as limited, and adaptation involves preferring positive, relationship-oriented emotions.

Chronic availability of emotion regulation goals in the elderly is evidenced by the results of many studies (e.g. Mather & Knight, 2005; Nashiro, Sakaki, & Mather, 2012; review in Mather, 2012). Several fMRI studies have shown, for example, greater dorsolateral and ventrolateral PFC activity and lesser amygdala activity in the elderly during passive watching of negative stimuli (faces or pictures) compared to neutral stimuli (Tessitore et al., 2005). This can be interpreted as being a more effective method of spontaneous emotion regulation in the elderly, and as an effect of greater focus on emotion regulation in late than in early adulthood (discussion in Mather, 2012). In studies where the participants were asked to actively process (rather than passively look at) the displayed stimuli, the elderly displayed greater PFC activation after positive than after negative stimuli than did younger people (Ritchey, Bessette-Symons, Hayes, & Cabeza, 2011). Thus, in the elderly, areas of the PFC are used either for active, complex perception of positive stimuli or for lowering the emotional response to negative ones (cf. discussion in Mather, 2012).

Yet another account of the emotional paradox in aging posits that negative emotions and stimuli have a less potent effect on the elderly than on younger people. This can be caused by the impairment of interoceptive processes: Older people are less effective in drawing inferences about their emotional state from such bodily cues as pulse, breath, blushing, or stomach sensations (Khalsa, Rudrauf, & Tranel, 2009, cited in Mather, 2012). A different explanation states that the priority of activating the amygdala for negative emotion processing decreases with age. This is supported by numerous studies (e.g. Tessitore et al., 2005; review in Mather, 2012). Lower activity of the amygdala in response to negative stimuli need not be a sign of poor function but could be, for example, the result of employing a different emotion regulation strategy (e.g. suppression rather than rumination or reappraisal, see discussion in Mather, 2012).

Each of the models presented above confirms the specific quality of processing emotional stimuli by people in late adulthood, though each proposes a different underlying mechanism. It is worth pointing out, however, that the given explanations do not contradict each other: They rather point towards a complex, multifaceted nature of this phenomenon. In contrast to young people, older adults react less intensely to negative situations and ignore negative stimuli more efficiently, which contributes towards maintaining emotional well-being in late adulthood. This phenomenon has been observed in relation to processing many different stimulus categories, including also verbal ones.

Results suggesting different responses to negative word stimuli in young and older adults were obtained by Molnár and associates (2013). These authors studied ERP characteristics in relation to age, observed in the process of distinguishing differently-valenced words. Molnár et al. show that higher N4 amplitudes are caused by negative words unrelated to the sentence. This proves the necessity of inhibiting activated, though contextually unrelated information. What is interesting, however, is that this relationship was much stronger in younger than in older people. One possible interpretation states that younger people are more sensitive towards negative stimuli, which remains in agreement with the emotion paradox theory.

The manner in which valence of differently conventionalized metaphors influences the ease of their processing by elderly people remains unclear. Valence was usually not controlled for in studies on metaphor processing – and in the cases where it was, the studies did not simultaneously control for conventionalization – and were carried out on younger populations. For example, Shibata et al. (2007) examined (via fMRI) the neuronal foundations of metaphorical – compared to literal and meaningless – sentence comprehension (with the structure of *An A is a B*). The participants were asked to silently read the sentences and state whether they were able to comprehend them. It was revealed that the degree of metaphoricity and conventionalization influences the patterns of brain activation: When reading short, new sentences, greater activation in the left medial frontal cortex, the left superior frontal cortex, and the left interior frontal cortex was observed. Rapp et al. (2004, 2007) have carried out research taking valence into account. There, the participants were asked to read short metaphorical and literal sentences (*An A is a B*), to rate their metaphoric content, and to state whether they had positive or negative connotations. The results have shown activation in a left lateralized network including the left inferior frontal gyrus and the left temporal lobe in cases where participants decided on the valence of metaphorical sentences. It is worth noting, however, that Rapp et al. did not focus on the differences caused by valence itself, but rather on differences in brain activity observed when rating the valence of metaphorical and literal sentences. Also, both of the aforementioned studies did not include the elderly as participants.

Studying the effect of valence on metaphor processing by the elderly thus seems to be an important future research goal. Whereas the influence of metaphor conventionalization appears to have been examined relatively thoroughly, the role of valence still requires further research. Conducting studies on this topic which would employ older adults, who exhibit different manners of emotional stimuli processing than do younger people, seems to be particularly interesting. Basing on a literature review, it can be expected that younger people will process positively-valenced sentences more rapidly, regardless of the degree of their metaphoric content (cf. the typical negativity bias in stimulus processing; Barrett i Bar, 2009; Van Berkum 2010), but that this effect will not be observed in the elderly. In that age group, differences in processing time between positive and negative utterances should not occur (cf. the emotion paradox), but longer RTs (in contrast with younger people) should be observed in relation to metaphorical sentences, especially those of unconventional nature. This prediction requires empirical confirmation, however.

## Conclusions

Summing up, in this article, several variables were discussed that could potentially influence processing metaphorical material by adults in late adulthood. Metaphor processing by the elderly is contingent upon a complex set of factors, which might result in inconsistent conclusions of research carried out on this topic thus far. The question involves not only interindividual variables (e.g. impairment of working memory, inhibition, and other specific cognitive functions, influence of neurocompensatory mechanisms), but also selected characteristics of metaphorical stimuli themselves (e.g. valence, conventionalization, syntactic complexity, etc.). The effect of valence on metaphorical stimuli processing by the elderly appears to be particularly interesting, though predictions on that point require solid empirical verification in the future.

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