Polish Psychological Bulletin
2012, vol. 43(2), 86-92
DOI - 10.2478/v10059-012-0014-5

Original Papers

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Attentional bias and emotion in older adults: Age-related differences in responses to an emotional Stroop task

The purpose of the study was to examine whether older adults show an emotional interference effect in a Stroop task, and whether their RTs differ with regard to age, gender and tendencies of mood regulation (to improvement and/or deterioration). The sample consisted of 60 participants at the age from 65 to 85. Emotional version of Stroop task and the Mood Regulation Scales were used. The results showed no significant differences in RTs to emotional and neutral words. Unexpectedly, a speeding effect was observed with the age of women. It appeared also that the effect of mood regulation tendencies was not significant for RTs. The last two effects are not consistent with the literature on cognitive and emotional aging.

Keywords: *Stroop task, emotional interference, older adults, emotional regulation*

Most studies on human functioning and development in the life span have shown the decline in multiple cognitive processes with age, especially in tasks which involve cognitive control (Verhaeghen and De Meersman, 1998; Davidson et al., 2003, Verhaeghen et al., 2005; Williams et al., 2007). In contrast to findings of cognitive changes, the studies on emotional regulation show a more optimistic view of aging. According to growing literature, emotional processing remains stable with age and even an increases of well-being and happiness is possible in late life (Carstensen and Mikels, 2005; May et al., 2005; Scheibe and Carstensen, 2010). However, the issue of factors which contribute to positivity effects of emotional regulation in the elderly is discussed in literature. It seems that one of the most interesting problems is the role of selective attention to emotionally relevant stimuli in processing of tasks involving cognitive control, such as the Stroop test (see review: Dalgleish, 2005; Chen, 2008; Schiebe and Carstensen, 2010).

The Stroop task (1935) is one of the most popular tasks used in the research on age-related differences in attention processes, inhibitory processes and executive control. Traditional Stroop test contains two experimental conditions: word inferential condition and control condition. In the first case, the color of printed words is not congruent with its meanings (e.g. word *red* printed in *green* ink). In case of the control condition, we show non-color words (printed in *black* ink) or non-word characters with different colors (e.g. patches or shapes). Stroop found that participants need longer time when they have to name the color of ink in which the item is printed when the items are printed in antagonistic colors. The difference between response time in these two experimental conditions is named as a Stroop effect or as an effect of interference.

Regarding the age-related changes, the research usually shows that the reaction time in traditional versions of a Stroop task decreases systematically from childhood to adulthood (Demetriou et al., 2002; Williams et al., 2007; see also: Bub et al., 2006). The life-span data have documented opposite tendency in adulthood: older adults show a greater increase in reaction time and errors in naming the print color of incongruent words than do younger adults (Uttl and Graf, 1997; Davidson et al., 2003; Williams et al., 2007). These data usually are considered in terms of increasing deficits in cognitive control which in later life may be due to reduced frontal function (see Adleman et al., 2002; Davidson et al., 2007).

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In the variant of an emotional Stroop task participants have to name the ink color in which neutrally and emotionally valenced words are printed. The emotional Stroop task elicits similar outcomes, i.e. a slowing effect in response to colored words, but engages a different mechanisms of interference (Dalgleish, 2005; Chen, 2008). This effect is not a function of conflict between a word meaning and a color of printed items but rather is a function of emotional meanings of the words, which capture attention and slow response time. Usually we say about emotional interference, but in fact emotional Stroop measures the attentional bias i.e. a tendency towards automatic focusing on a well-learned and automatic activity (reading) at the cost of a proper but less automatic task of color naming. It appears that color-naming of emotional words is slower in groups of emotionally disturbed people than in control groups (see review: Williams et al., 1996; Dalgleish, 2005; Chen, 2008). For example, the color-naming latencies in naming emotional words were observed in samples of patients with anxiety, even in students with mild depression, in persons with post-traumatic stress, etc., when – generally speaking – meanings of words (content of items) were related to experiences and/or ruminations specific for individuals from these samples (e.g. naming the color of depressive words by depressive persons). The effect of emotional interference was also observed when participants have to name the ink color of self-relevant (e.g. *egoistic*, *happy*) and taboo (e.g. *orgasm*, *sexual*) words (Siegrist, 1997). The findings suggest that the performance of emotional Stroop tasks is related to the content of materials and support the assumption that the performance is a result of selective attention to emotionally relevant stimuli of those tasks the processing of which would be disruptive (see review: Williams et al., 1996; Dalgleish, 2005; Chen, 2008).

Studies on the age-related changes involving healthy population in emotional Stroop test are fewer and less consistent. We know only three studies in this field. Wurm et al. (2004) found the interference effect only in the group of older adults (not in younger) using two versions of an emotional Stroop task: in the auditory Stroop to an emotional tone of voice (incongruent with the meaning of the heard word), and in the verbal paradigm to arousal levels of the words read. However, the Stroop effect was not observed in this study to the valence of words, both in younger and older groups. Contrary to these data, Ashley and Swick (2009) findings suggest that both younger and older adult groups showed an emotional Stroop effect on the valence of pure blocks of words: slower responses to emotional, relative to neutral, block of words. However, a positive effect of aging was observed in this study in the randomly mixed block of emotional and neutral words, showing an age-related diminishment of emotional interference effects. On the other hand, using pure blocks of verbal Stroop, LaMonica et al. (2010) found that older adults, unlike younger, performed better (accuracy) on the affective (positive and negative) than the neutral conditions, which suggests also an age-related diminishment of emotional interference. Diminished responses to affective stimuli usually are considered in terms of positivity effect of aging in emotional regulation, which may be due to decreased activation and signaling in the amygdala subcortical system, associated with emotional responding (Williams et al., 1996; LaMonica et al., 2010; see also: Schiebe and Carstensen, 2010).

It should be emphasized that all above studies on age-related changes in emotional Stroop were focused on the differences between younger and older adults. Contrary to our study, the changes in the size of Stroop effects during an old adulthood (60+) were not systematically explored. On the margin of main analyses, LaMonica et. al. (2010) mentioned only that the pattern of performance on affective and neutral conditions did not differ among individuals in the 60s and 70s age groups. In this context the following question arises: whether the age-related tendency to emotional interference diminishment, reported by LaMonica et al. (2010) and by Ashley and Swick (2009), does not continue in the period of late adulthood?

Despite aging naturally associated with older adults' experience of decline, losses and ending, a lot of research has shown positive affective changes with age, indicating that the relatively high level of well-being and emotional stability is the norm rather than the exception, even in late adulthood (Carstensen and Mikels, 2005; May et al., 2005; Scheibe and Carstensen, 2010). According to the theory of socioemotional selectivity (Carstensen, 2006; Schiebe and Carstensen, 2010), a subjective short future time perspective of elderly shifts motivational priorities to an increase of importance of the emotional states regulation. Among others, the result of this motivational shift is that older adults tend towards emotional balance, focus on positive materials and/or reduce focus on negative materials. However, we can find some empirical data which show rather small age-related decrease of positive affects and affective balance, and even a small age-related increase of negative emotions in older adults (Pinquart, 2001). These tendencies seem to be the strongest in cohorts of older adults from the former communistic Eastern European countries (Pinquart, 2001). Some data on age-related changes in emotional regulation are evidently not consistent with Carstensen's positivity effect hypotheses. For instance, Gruehn et al. (2005) have documented no aging bias favoring memory for positive materials. Stanley and Isaacowitz (2011), revealing in the cluster analysis four subgroups of mood-change trajectories, have documented that older adult, in comparison with the younger, were the members of both most positive and most negative subgroups. On the basis of this kind of research it seems that not all older adults experience a higher positive affect than the younger. On the other hand, presented above data suggest that both positive and negative stimuli may capture the attention of individuals, and that not only age-related experiences but also the socio-cultural context of development may affect different trajectories in emotional aging.

According to the above considered empirical findings on age-related changes in an emotional Stroop task, we can assume that older adults will show an increasing diminishment of emotional interference with age, i.e. an age-related decrease of differences in RTs to emotional words in relation to neutral. Taking the theory of socioemotional selectivity into account, we would like to examine whether the possible changes in emotional interference in older adults are related to age of the elderly and a positivity bias to the mood improvement in their emotional regulation. No gender differences were expected.

Method

Participants

The data were obtained from community-based sample (N = 60) of healthy, noninstitutionalized men (n = 19) and women (n = 41) ranging in age from 60 to 85 years (M = 68 years, SD = 6,64) living in the urban (n = 30) and suburban (n = 30) areas of central Poland. All participants were volunteers. The proportions of males to females (19/41) and the level of education in the sample (basic/secondary/higher: 28/27/5) were similar to their distribution in the general population of the elderly in Poland. The sample was collected using “door to door” and “snowball” techniques. Exclusion criteria included evident motor disabilities, participants’ declaration of drug or alcohol abuse and any psychological or neurological disorders. All participants spoke Polish as their first language.

Measures

Stroop Test. In the present study, the emotional analog of Stroop task was used. In the study 45 words of different emotional meanings (15 negative, 15 positive, and 15 neutral) in one of three colors (red, yellow and green) were displayed separately on a computer screen (17 in.). Each word (typed in New Roman, font size 100 pixels) was presented two times in the total series in the random sequence of exhibited words and their color. The lists of used words were established in the pilot study on the valence words ratings by elderly. The participants were asked to indicate the color of word (font color) pushing one of three buttons (red, yellow or green) as quickly as possible. The next word was exhibited in a time interval of 200 ms after reaction. The average time reaction to all words and average time reactions to words with different emotional connotation (positive, negative and neutral) were computed in the test.

The Mood Regulation Scales (MRS) by B. Wojciszke (2003, Skale Regulacji Nastroju). This instrument is designed to measure mood regulation and consists of two independent scales: the *Mood Improvement Scale* (MIS) and the *Mood Deterioration Scale* (MDS). Each of these scales consists of 15 items. MIS includes 11 items describing various ways of thinking which increase negative emotions, and 4 items describing the reduction of positive emotions. MDS includes 12 items describing various ways of increasing positive emotions and 3 items describing the reduction of negative emotions. The response scale ranged from *never* (1) to *always* (5). MIS and MDS have satisfactory psychometric characteristics (Wojciszke, 2003). The Spearman-Brown split-half reliability coefficient for MIS was 0.83 and 0.89 for MDS. The alpha Cronbach homogeneity coefficients for MIS was 0.84 and 0.89 for MDS in a sample of adults (N=181, range 19-58 years). Factor analyses of the questionnaire and analyses of relationships between MIS, MDS and other instruments measuring mood and emotions have provided evidence for the concurrent validity of the scales. In the current sample alpha Cronbach reliability coefficients are 0.83 for MIS and 0.78 for MDS.

Control and descriptive variables. We included the following variables: age (younger elderly adults 60-69 and older elderly adults 70-85), gender (female, male). These variables were assessed on the basis of participants’ declarations.

It should be mentioned here that in the frame of other research program the same sample was used, and in a separate session syllogistic reasoning, working memory, and anxiety were measured.

Results

We examined the participants’ reaction times in three experimental conditions of emotional Stroop test: in response to randomly mixed block of positive, negative and neutral words. The goals were to find whether the elderly show an interference effect, and whether they differ in gender and in tendencies of mood regulation. In the first step the data were analyzed in repeated measure 3 x 2 x 2 ANOVAs with Valence (positive, negative, neutral) as the within-subject factor, and Age (younger elderly, older elderly) and Gender (female, male) as the between-subjects factors. In the next step, Improvement (high, low) and Deterioration (high, low) in mood regulation was included in the model. A few complementary data analyses were used.

Reaction times

The results of analyses indicated a significant main effect of Age (F[1,56] = 6.09, p = 0.01) with reaction times for younger elderly adults (60-69 years, M = 656.16; SD = 78.45) slower than older elderly adults (70-85 years, M

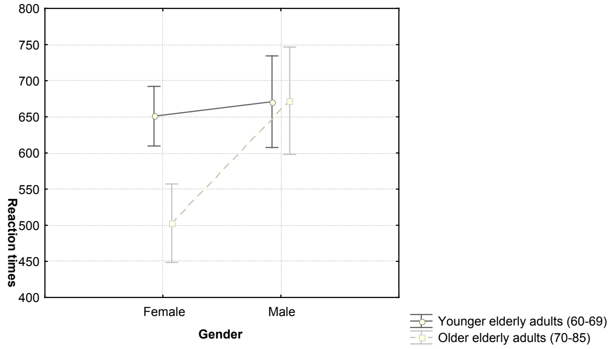

Figure 1. Reaction times for gender in the groups of younger elderly and older elderly adults.

Table 1
Means (M) and standard deviations (SD) for reaction times (RT in ms) in the positive, negative and neutral experimental conditions of the Stroop test.

Condition	M	SD
Positive	628.4	124.4
Negative	620.7	132.3
Neutral	611.7	130.8

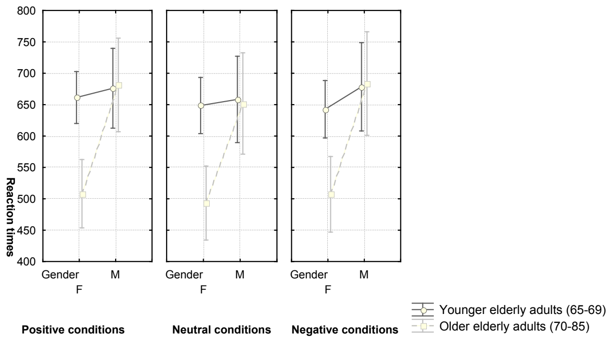

Figure 2. Reaction times for gender and age groups in positive, negative and neutral conditions.

= 563.3; *SD* = 156.16). A significant main effect was also shown for Gender ($F[1,56] = 10.16$, $p = 0{,}002$), suggesting that reaction times of female were shorter than in the male group ($M = 596.93$ and $M = 671.58$, respectively). Additionally, the results indicated an interaction effect for Age x Gender ($F[1,56] = 6.21$, $p = 0.01$) with reaction times for older elderly women shorter than younger elderly women (Fig. 1).

A speeding effect in the group of aging women was surprising and we decided to conduct additional analyses, including Correctness (3 levels of mistakes) in the model. It appeared that there was no main effect of Correctness for reaction times. However, interaction Gender x Correctness was demonstrated: women faster in responding make also more mistakes ($F[6,94] = 2.38$; $p > 0.034$).

Interference effect

Table 1 summarizes participants' reaction times in three experimental conditions, when positive, negative and neutral words were displayed.

Unexpectedly, an effect of Valence was not demonstrated ($F[2.112] = 2.14$, $p = 0.123$), not confirming the emotional Stroop effect. Additionally, the interaction of Valence x Age x Gender was not significant ($F[2.112] = 0.108$, $p = 0.89$), showing that patterns of Age and Gender responses to positive, negative and neutral conditions were the same, which confirms the lack of emotional Stroop effect (Fig. 2).

Mood regulation

Additional ANOVAs included Improvement (high, low) and Deterioration (high, low) as predictors for Valence (positive, negative, neutral), revealed no significant effects ($F[1.56] = 0.030$, $p = 0.86$, and $F[1.56] = 0.344$, $p = 0.55$, respectively). The Spearman rang correlations showed only two statistical tendencies: older adults with a tendency for mood deterioration showed shorter responses to positive ($R = -0.24$, $p = 0.056$) and negative words ($R = -0.25$, $p = 0.051$).

Discussion

The main purpose of the present study was to examine age-related differences among elderly adults in their responses to randomly mixed block of words of an emotional Stroop task. Firstly, the obtained results did not confirm an emotional Stroop effect in the studied sample of older adults: the differences in their RTs to emotional and neutral words were not significant, independently of the age and gender. Secondly, results indicated a speeding effect with the age of women: the RTs of older elderly women (70+) were significantly shorter than those of younger ones and shorter in relation to the group of men. Thirdly, the present analysis revealed that the strategies preferred by the elderly for improvement or deterioration of the mood cannot be treated as good predictors of emotional processing in a Stroop task.

In the discussion it should be pointed out that the present data, which do not confirm an emotional interference in older adults, are consistent with Wurm's et al. (2004) findings that in the group of healthy older adults although the Stroop effects appear on the arousal levels of words they do not appear on their valence. However, authors noted that the failure to observe the effect of valence in this study may be a result of "carefully equated arousal across the three valence conditions (neutral, positive, negative)" (p. 529). On the other hand, our data are not consistent with Ashley and Swick (2009) findings which generally support the hypothesis of an interference effect on valence in the healthy elderly. Ashley and Swick (2009) observed interference effects (slower RTs to emotional words, in relation to neutral ones) both in young and older adults, using a pure block of emotional and neutral words. However, positive aging effects (i.e. diminishment of interference effects in older adults as compared to younger ones) was observed by them on mixed blocks of emotional and neutral words, but not on pure blocks. Contrary to Wurm et al. (2004), and to Ashley and Swick (2009), LaMonica et al. (2010) found positive aging effects on the valence of words, using a pure block of emotional and neutral words. The data analyses presented in their study suggest that contrary to younger adults, older people (60+) performed better on affective than neutral conditions.

The present study supports LaMonica et al. (2010) findings demonstrating the ability of older adults to manage emotional stimuli, cognitive incongruity and inhibition, which is consistent with the hypothesis of positivity effect of aging, described in the theory of socioemotional selectivity by Carstensen (2006; Schiebe and Carstensen, 2010). Additionally, the present study unequivocally demonstrates that the age-related tendency for diminishment of interference effects, observed in comparison of younger and older elderly groups, is not a continuous process during the period of old adulthood: the younger (60s) and older (70+) groups did not differ from each other. It suggests that susceptibility to emotional disruption is not a linear phenomenon and probably the changes in patterns of performance on emotional and neutral conditions are crossed at some threshold point before old adulthood. This supposition is very important from the perspective of life-span developmental psychology, which needs a more dynamic, and rather longitudinal designs of the future studies on age-related differences in this area.

The intriguing problem for future research is a main effect of gender observed in the present study and a speeding effect with age of elderly women in responses to emotional and neutral stimuli. Meta-analyses of the data indicated a resistance to interference in older adults and a general slowing effect in cognitive control (Verhaeghen and De Meersman, 1998; Verhaeghen et al., 2005; see for discussion: Sliwinski and Hall, 1998). In line with this kind of thinking, the speeding effect of overall reaction times with age of older adults was rather not expected in our study. In this context, we were surprised to find out that this effect was specific for the group of aging women, and not for men, who demonstrated a stable with age level of overall RTs to stimuli of an emotional Stroop task (see Fig. 1). These findings are not consistent with the results of other studies using an emotional Stroop task in a healthy population of the elderly, where no significant gender differences were observed (Ashley and Swick, 2009; LaMonica, 2010) or where this problem was omitted (Wurm et al., 2004). However, we can find data documenting that women are consistently faster than men during processing of Stroop task (see Mekarski et al., 1996).

In the light of many inconsistencies across studies and/or methods there is no good explanation of age-related gender differences in an emotional Stroop task. Because behavioral evidence is not clear, the contemporary discussion on age-related gender differences in emotional processing is focused on findings in neuroscience. In these frames the possible interpretations may be related to the problem of gender differences in patterns of brain atrophy (Gur et al., 1991; Xu et al. 2000), and lateralization of an emotional activity (see Harrison, Gorelczenko, Cook, 1990; Killgore and Yurgelun-Todd, 2001; Wager et al. 2003). The findings indicate that the amount of brain atrophy is rather greater in elderly men than women and is more lateralized (in right or left direction relative to regions), whereas the age effects in women are more symmetric. It suggests that women might be generally less vulnerable to age-related changes in cognitive abilities. Additionally, the speeding effect with age of women, as compared to men, might be interpreted as the result of age-related reduction in amygdala activity reflecting an inability to elicit strong negative emotions (see St. Jacques et al., 2009b, Ness et.al., 2009). It is possible that this effect is associated with the hormone level decrease with age, more dramatic for women than for men, e.g. a decrease of estrogen, whose receptors are located in the amygdala. It must be noted, however, that neuroscience findings on gender differences in emotional processing are also inconsistent across studies and/or used methods. Looking for exhaustive explanation with full responsibility we can only say that future research is need.

Finally, we would like to consider the results of our study on the relationship between mood regulation and emotional processing in a Stroop task. According to the theory of socio-emotional selectivity (Carstensen, 2006; Schiebe and Carstensen, 2010) we assumed that the positivity effects in emotional aging are associated with an increase of motivation to regulate emotions, which leads both to a reduction of responses to emotionally negative stimuli and to an increased attention to emotionally positive stimuli. However, the present study showed that responses to emotional stimuli were not affected by mood regulation strategies reported by older adults. It is worth mentioning that cluster analyses, which we conducted additionally, showed no significant differences in RTs both in the largest improvement [$F(2.112) = 1.07$, $p = 0.34$] and largest deterioration [$F(2.112) = 0.07$, $p = 0.49$] subgroups of older adult. These data suggest that the patterns of responses to emotional stimuli and self-reports about the ways of mood regulation (to improvement and/or deterioration) revealed in our study are independent. From the methodological point of view we know that how people behave and what they relate about own behavior is not the same. On the other hand, we can find data documenting a lower relationship between subjective arousal ratings and objective physiological arousal (SRC) in the elderly, as it is observed also in patients with amygdala damage (Neiss et al., 2009). Moreover, functional neuroimaging studies indicated that the impairment in the relation between the valence of stimuli (negative) and its subjective rates (more neutral) is associated with a subsequent decrease in amygdala activity (St. Jacques et al., 2009b). Neiss et al. (2009) suggest that impairments in relations between subjective and objective arousal (physiological) occurred for both positive and negative emotions. In line with these considerations, an intriguing question arises whether it is possible that the age-related changes in amygdala (or possibly in functional relation with other structures, e.g. prefrontal cortex, as suggested by St. Jacques et al., 2009a, 2009b) lead to the disconnection between subjective state-experienced ratings or reports and objective responses to emotional stimuli in the elderly. It seems that the examination of this problem may help us in the future to understand better the relation between conscious and/or automatic processing of emotional information.

The present study needs to be replicated because of many limitations. Firstly, the "snowball" sampling would limit the group of participants to a homogeneously specific circle of elderly, producing an effect of selectivity in the present study. Secondly, a mixed block of words used in the study might produce a "carry-over" effect of emotional and neutral meanings of words, decreasing an emotional interference in a Stroop task (Ashley and Swick, 2010; see also: Ludwig et al., 2010). Thirdly, the computer version of the Stroop test requires probably a simpler automatic reaction to the color of printed words than in a traditional version, where the naming of the words might engage additional processing resources involved in the semantic analysis of the word content (Dalgleish, 2004). Finally, the role of the socio-cultural context should be examined in the future research on emotional interference in a Stroop task because of a specific political and economic changes in Poland that affected cohorts of older adults in the sample of our study (Pinquart, 2001).

Acknowledgments

The present study was based on the data collected by Magdalena Dunajska, Magdalena Szumska and Aleksandra Mrówka. We are indebted to many people who collaborated with us during data collection and preparation of this paper, especially to Tomasz Terpiłowski for proofreading of our paper.

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