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Age-Related Differences in Altruism Across Adulthood:
Making Personal Financial Gain vs. Contributing to the Public Good

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At the time of data collection of Study 2 Fredda Blanchard-Fields was at the Georgia Institute of Technology, School of Psychology, Atlanta, GA, USA. Sadly, Fredda Blanchard-Fields died on August 3rd, 2010, so she could not be involved in Studies 3 and 4. However, she was involved in the conception of this research as well as in the discussion of results of Study 2 and the writing of a previous version of this manuscript based on Study 2. Address correspondence to Alexandra M. Freund at the University of Zurich, Dept. of Psychology, Binzmuehlestrasse 11 / 14, CH – 8050 Zurich, email: freund@psychologie.uzh.ch.

Abstract

Four studies utilizing different methodological approaches investigated adult age-related differences in altruism (i.e., contributions to the public good) and the self-centered value of increasing personal wealth. Data from the World Values Survey (Study 1) provided first evidence of a negative association between age and the self-reported wish to be rich. Ecological concerns, a form of contributing to the public good, were positively related to age. Study 2 investigated whether these values are expressed behaviorally when participants solved a complex problem that allowed striving for monetary gains or contributing to a public good. Confirming hypotheses, young adults' strategies were consistent with the aim of optimizing personal financial gain, and older adults' strategies with the aim to contribute to the public good. Studies 3 and 4 showed that older adults were more likely than younger and middle-aged adults to donate money to a good cause than to keep it for themselves. Study 4 manipulated participants' future time perspective as a factor potentially contributing to age-related differences. Partly confirming hypotheses, a longer time perspective reduced donations by older adults, but a shorter time perspective did not increase donations by younger adults. These studies suggest that older adults not only report valuing contributions to the public good more highly but also are more likely to behave altruistically than younger adults. All studies used cross-sectional designs that prevent a strict test of developmental trajectories but rather provide age-related differences at one point in time, representing a first step in investigating adult age-related differences in altruism.

Key words: Values, Altruism, Materialism, Ecology, Public Good, Adult

Development

Age-Related Differences in Altruism Across Adulthood:

Making Personal Financial Gain vs. Contributing to the Public Good

Personal greed has been blamed as one of the factors contributing to the financial crisis that occurred in 2007/2008 and is still haunting us (Hansen & Movahedi, 2010). In the wake of this crisis, many believe that people ought to contribute to the public good, care for others, and protect the environment and that personal greed needs to take a back seat. Arguably, the functioning of civil societies is based on their members' contributions to the public good, which allow the establishment of such institutions as schools or health care and the building of infrastructure (e.g., streets, water and waste systems). Members of most societies have to contribute to the public good by paying taxes. In addition, some people contribute voluntarily to the welfare of specific needy groups (e.g., the poor, victims of war or natural catastrophes) through charitable donations. Although many people highly value this form of altruism, they may nevertheless behave in ways that optimize their personal financial situation (cf. attitude-behavior gap, Eagly & Chaiken, 1993). There is presently a dearth of psychological studies investigating actual behavior related to self-serving versus altruistic values. The present research addresses this gap with a series of studies moving from self-reported values (Study 1; including a US-American and a Swiss sample) to behavior in a complex problem solving task pitting one's actual personal financial gain against the ecological preservation of a hypothetical apple orchard (Study 2 in a sample of young, middle-aged, and older Swiss adults) to the decision between keeping money for oneself versus donating it to a good cause (Studies 3 and 4 with independent samples of young, middle-aged, and older Swiss adults). Based on the hypothesis that altruism—in the sense of a willingness to contribute to the public

good, such as the environment or charitable donations—increases with age, these studies investigate adult age-related differences in self-reported and behavioral altruism. As will be elaborated in more detail below, this hypothesis is based on the assumption that maximizing one's own resources becomes less important with increasing age (Freund & Riediger, 2001), and that the shorter future time perspective associated with older adulthood activates altruistic values (see also Brandtstädter, Rothermund, Kranz, & Kühn, 2010; Ritter & Freund, in press).

Defining altruism. A well-known definition of altruism was proposed by Batson and Shaw (1991) and suggests that altruism denotes a “motivational state with the ultimate goal of increasing another's welfare” (p. 109). Batson and Shaw contrast altruistic motivation with an egoistic motivation that is directed at increasing one's own welfare. The two motives are proposed to be independent of each other. Using a different conceptualization of altruism, Mayr and colleagues (Mayr, Harbaugh, & Tankersley, 2009) distinguish between “pure altruism” and “warm glow altruism” in the following way (p. 306): “If the public good is welfare for the poor, then warm-glow altruists give because of the good feeling *they* get from giving, while pure altruists give to make the poor better off.”

Harbaugh, Mayr, and Burghart (2007) demonstrated empirically that “warm-glow” motives are related to the hedonic response as measured by activation of related brain regions when one contributes money to the public good. This association is stronger for voluntary donations than for mandatory contributions to the public good (i.e., taxes) even though the latter form of “pure altruism” also activates brain areas associated with reward processing. This suggests that people derive more pleasure from altruistic acts that

are voluntary and imply a sense of agency and goodness on the part of the donor than from “purely” altruistic acts such as paying taxes in order to contribute to the public good.

Economists define “public goods” as goods that are not consumed by a single individual or group and that are accessible or usable regardless of whether one has made a contribution to the respective good oneself. Mayr and colleagues cite a clean environment as one of the classic examples of a public good. Thus, in Study 2, we define altruism as behavior contributing to the public good of a clean environment that is performed even if one will not personally profit from this good. Similarly, charitable giving is typically targeted at a specific group (e.g., victims of a food crisis or environmental disaster) and does not directly benefit the donor. Hence, Studies 3 and 4 used voluntary charitable giving as an indicator of altruism.

Age and altruism

Whereas the motivational model by Batson and Shaw (1991) suggests that altruistic behavior results from altruistic motives, the warm glow model of altruism links contributions to the public good to hedonic consequences in the donor (Mayr et al., 2009). In the present paper, we do not go into whether altruistic acts ultimately benefit the person behaving altruistically, a question that has long been debated by philosophers and psychologists (see Batson & Shaw, 1991). Instead, adopting a developmental perspective, we focus on *age* as a factor that might be associated with altruistic behavior. Beyond childhood, we could only find one study investigating age-related differences in altruistic behavior. Midlarsky and Hannah (1989) investigated donation behavior (here, for infants with birth defects) in a convenience sample aged 5 to 75+ years in a shopping

mall. The authors aimed to determine how many people in each age group gave charitable donations at a public stand in a shopping mall. They found that the number of donors and the size of donations increased with donor age (up to age 75 years). The authors interpreted this donation behavior as indicating an age-related increase in altruism. However, note that the donations were made in a public setting, thereby increasing demand characteristics. Older adults might be particularly prone to respond in socially desirable ways (Stöber, 2001).

Generativity as a form of altruism. One line of research suggesting that there might be age-related differences in altruistic behavior is that on generativity. Generativity can be seen as a facet of altruism as it reflects caring for the well-being of future generations by helping to provide better living conditions for them (e.g., Erikson, 1982). Ecological concerns fit this definition. Typically, exploiting the environment has delayed effects that have to be dealt with primarily by future generations. Conversely, attaining a positive ecological legacy often comes with personal costs including higher prices for products and possible constraints on personal financial gain.

Erikson's theoretical notion of age-related changes in generativity is supported by empirical evidence that middle-aged adults demonstrate greater self-reported and behavioral generativity than young adults (McAdams, de St. Aubin, & Logan, 1993; McAdams, Diamond, de St. Aubin, & Mansfield, 1997; but see Whitbourne, Zuschlag et al., 1992). Interestingly, according to this research, generative *concerns* remain stable from middle into older adulthood, but generativity-related *behaviors* decrease. This might be due partly to fewer opportunities to display generative behavior due to children leaving home, retirement, and other age-related life events (e.g., health). To address this

potential problem of some of the generativity studies, in the present Studies 2, 3, and 4, we made sure that adults of all ages had the same opportunity to display altruistic behavior.

The role of resources for age-related differences in altruism. One of the reasons for hypothesizing age-related differences in altruism is that the availability of resources changes across adulthood. Younger adults might be less willing to spend resources such as money on anything but themselves because they need these resources to achieve important developmental goals. Taking an evolutionary perspective, Freund and Riediger (2001) argued that the accumulation and display of resources is particularly important in young adulthood. First, young adults typically have not yet had the same amount of time and number of opportunities to acquire and accumulate resources as middle-aged or older adults have. Resources such as money are important to ensure one's survival by providing access to goods such as nutritious food and health care. Moreover, having access to resources also enhances the probability that one's offspring will survive. In addition, the display of resources increases one's mate value (e.g., Buss, 1999), which, in turn, increases the likelihood of having access to attractive (i.e., resource-rich) partners for reproduction. As research on subjective well-being has shown, however, it is not the absolute amount of resources that is most important (e.g., Diener, Suh, Lucas, & Smith, 1999), but one's standing compared to others and one's gain in resources over time (Frederick & Loewenstein, 1999). Thus, younger adults should be oriented towards acquiring and accumulating more and more resources for themselves (see also Staudinger, Marsiske, & Baltes, 1995). This assumption is in line with the literature on personal goals. Younger adults report having more personal goals geared towards gains

than towards the maintenance or avoidance of losses (e.g., Ebner, Freund, & Baltes, 2006; Heckhausen, 1997) and they are more persistent in pursuing goals that might increase gains than in pursuing goals that counteract losses (Freund, 2006).

In contrast, middle-aged and older adults have typically already accumulated the resources necessary to protect their own and their offspring's survival. By middle adulthood, most people have a life partner and raised their offspring, making it a more pressing task to contribute to the survival of potential grandchildren and their offspring by contributing to generally good living conditions in one's immediate and extended environment.

The potential role of future time perspective. Another factor that might contribute to age-related differences in altruism might be that future time perspective decreases with increasing age (Lang & Carstensen, 2002). Brandtstädter and colleagues (2010) suggest that a shorter future time perspective is related to the prioritization of what they call “ego-transcending” over extrinsic-instrumental goals geared towards personal benefits. In contrast to the perspective offered by socio-emotional selectivity theory (SST; Carstensen, Charles, & Isaacowitz, 1999), Brandtstädter and colleagues argue that a limited time perspective does not trigger goals that lead to immediate gratification but, instead, activates a value perspective that transcends the present and offers meaning (for a more detailed elaboration on this issue, see Ritter & Freund, in press). They state, “through the fading of personal future, ego-transcending or ‘timeless’ moral and ethical perspectives can gain influence on the person’s selection of goals and activities” (p. 153).

In a series of studies, Brandtstädter and colleagues found that self-reported values differed across adulthood with older adults reporting lower extrinsic-instrumental goals,

including personal success, status, competence, and higher ego-transcending values, including authenticity, spirituality, and altruism. In a second study, they demonstrated that priming a limited future time perspective by reminding participants of their own mortality could induce such age-related differences. Unfortunately, this design confounds mortality salience effects, which strengthen the endorsement of certain values (e.g., Pyszczynski, Greenberg, & Solomon, 1999), with the effects of time perspective. Moreover, Brandstädter and colleagues did not analyze altruism separately from other ego-transcending values in their study. They also did not include behavioral measures. These shortcomings will be addressed in the current paper.

The present studies. We are not aware of any studies that have tested directly whether there are age-related differences in altruism when a self-serving financial opportunity and an opportunity to contribute to the public good (e.g., by protecting the environment or donating money) are juxtaposed. This was one of the aims of Study 2. Moreover, we used a multi-method approach including self-reported problem-solving behavior and actual donation behavior. Study 1 tested whether there are age-related differences in the endorsement of financial values and ecological concerns. Study 1 is based on the self-reported endorsement of these values across adulthood based on data from the Word Value Survey. Study 2 used a complex problem-solving task that allowed us to observe behavior geared towards maximizing personal financial gain or optimizing the ecological state of a fictitious apple orchard. Studies 3 and 4 complement the previous studies by investigating actual donation behavior. In Study 3, participants could either keep the money they had earned for participating in a previous, unrelated study or donate it to a good cause (viz., Doctors Without Borders). We hypothesized a positive

association between age and the likelihood to donate money to a good cause. Finally, Study 4 included future time perspective as a factor that may contribute to adult age-related differences in altruism.

Study 1

Study 1 addresses the question of age-related differences in values using self-report in a very large and heterogeneous sample. Data were obtained from the World Values Survey (WVS, 2009) that includes two questions on values that are of particular interest to the present research question, namely, that of being rich and that of protecting the environment (Schwartz, 1994). The fifth (and most recent) wave of the WVS was carried out between 2005 and 2008. In order to achieve comparability to samples that were recruited for the subsequent studies in Switzerland, we selected the subsample of Swiss adults aged 18 years or older. We expected the materialistic value of wanting to be rich to be negatively related to age and the altruistic value of protecting the environment to be positively associated with age.

As is true for all samples that are drawn from one nation, one could argue that Swiss nationals might be different from other nations such as the U.S.A. regarding age-related differences in values. Although an examination of cultural or national differences is beyond the scope of this paper, Study 1 also included a U.S. American sample from the WVS to address this topic.

Method

Sample. Selecting a subsample of Swiss adults who were at least 18 years of age resulted in a sample of $N = 1,241$ adults aged 18 to 86 years ($M_{\text{age}} = 52.45$ years, $SD = 16.14$), of which 55.1% were women, 18.3% single / never married, 57.8% married or

living together, 15.0% divorced, and 8.7% widowed. As for employment status, 61.3% reported that they were employed full- or part-time or self-employed, 1.0% unemployed, 2.9% students, 6.0% housewives not otherwise employed, and 27.9% retired.

The U.S. American sample included $N = 1220$ adults aged 18 to 91 years ($M = 47.96$, $SD = 17.02$). Fifty percent were women, 22% single / never married, 58% married, 14.4% divorced / separated, and 5.6% widowed. Fifty seven percent reported being employed full- or part-time or self-employed, 3.4% unemployed, 2.9% students, 8.1% housewives not otherwise employed, and 19.5% retired.

Measures

Values. To assess the endorsement of valuing personal wealth and environmental concerns, we used two items from the Schwartz Value Survey (Schwartz, 1994) that ask participants to rate how much a person described in the statement resembled them on a scale ranging from 1 (*very much like me*) to 6 (*not at all like me*). The two items read: “*It is important to this person to be rich*” (Swiss sample: $M = 4.89$, $SD = 1.10$; U.S. American sample: $M = 4.58$, $SD = 1.19$) and “*It is important to this person to look after the environment*” (Swiss sample: $M = 2.19$, $SD = 1.00$; U.S. American sample: $M = 2.54$, $SD = 1.24$). For further analyses, the scores were reversed (i.e., higher scores indicate higher importance of the respective value).

Household income. Self-rated income was included as a control variable that might potentially contribute to age-related differences in the value of being rich and that of caring about the environment. The World Values Survey does not include measures of amassed wealth, which might be an even better indicator of one’s financial situation. However, although economists point out that the relation between income and wealth is

complex (Kennickell, 1999), “the two are related to a considerable extent” (Reynolds, 2006; p. 150), allowing us to use income as a proxy for wealth. As perceived relative income might be a better psychological indicator of one’s relative financial standing than objective income, participants rated their household income relative to all other households in their country on a 10-point scale (ranging from 1 = *lowest income decile* to 10 = *highest income decile*) (Swiss sample: $M = 5.43$, $SD = 1.78$; U.S. American sample: $M = 5.04$, $SD = 1.86$). In Swiss sample, self-rated household income was slightly negatively related to age ($r = -.08$, $p = .01$) and unrelated in the U.S. American sample ($r = .002$, n.s.).

Results

A regression analysis for each of the two self-reported values was conducted with value as a dependent variable and income (Step 1) and age (Step 2) as predictors. For the importance to be rich income emerged as a significant predictor (Beta = .13, $p < .001$; $R^2 = .02$); entering age in Step 2 yielded a significant increase in R^2 ($= .02$, $p < .001$; Beta = -.13, $p < .001$; $R^2 = .034$). Thus, the importance of being rich is negatively related to age.

As for the importance of looking after the environment, the corresponding regression analysis revealed no effect of income (Beta = -.045, $p = .14$; $R^2 = .002$), but showed a significant increase in R^2 when age was entered into the regression equation (Beta = .23, $p < .001$; $R^2 = .054$). Thus, the importance of looking after the environment was found to be unrelated to income, but positively related to age.

Results for the U.S. American sample mimic those for the Swiss sample: After controlling for self-reported income, age was related to a lower wish to be rich (Beta = -.12, $p < .001$; $R^2 = .051$) and a higher value of caring for the environment (Beta = .13, p

< .001; $R^2 = .015$). Thus, it seems that the finding of a low but significant associations between age and materialistic vs. environmental values are not specific to the Swiss.

Discussion

Taken together, data from the World Values Survey provide first and preliminary evidence in support of the hypothesis that age is positively related to the endorsement of environmental values, and negatively associated with the endorsement of self-serving monetary values. The associations between these two values and age, albeit small, were found reliably for a Swiss and an U.S. American sample. As the World Values Survey is based exclusively on self-report data and single-item indicators of values, Study 2 used a design that required repeated decisions to protect the environment or to maximize one's financial gain in a problem-solving task.

Study 2

Contrary to many findings in cognitive aging research, studies investigating everyday problem solving show no or even positive age-related differences in the use of instrumental problem solving strategies (e.g., Blanchard-Fields, Jahnke, & Camp, 1995; Blanchard-Fields, Mienaltowski, & Seay, 2007; Cornelius & Caspi, 1987). Young and older adults seem to be equally able to find solutions to everyday problems. On the basis of these results, we decided to develop a complex problem-solving task that allows repeated assessments of behaviors of young, middle-aged, and older adults over the course of an experiment. In other words, in Study 2, we used a complex problem-solving task that we could analyze on a trial-by-trial basis. It was a task that participants could perform using different strategies for which we expected to observe age-related changes. Specifically, we investigated adult age-related differences in the use of strategies aimed at

maximizing one's personal financial gain compared to those aimed at maximizing one's contribution to a public good (viz., preserving the environment). Moreover, as is rarely done in studies on age-related changes in complex problem solving (but see Blanchard-Fields et al., 1995), we included a group of middle-aged adults in order to gain insight into age-related differences across adulthood.

The task, which will be described in more detail below, was set up in such a way that, depending upon the strategy employed across trials, the outcomes were to some extent negatively correlated but not mutually exclusive, thereby allowing participants to a certain degree to contribute to a public good by behaving in an ecologically responsible way while, at the same time, making some money (and vice versa). We hypothesized that young adults focus on maximizing their personal gains, whereas older adults focus more on contributing to a public good (viz., preserving the environment). Middle-aged adults were expected to opt for the middle path of focusing on both to a moderate degree.

Method

Sample. Younger adults were recruited through flyers posted at the University of Zurich. Middle-aged and older adults were recruited using ads in local newspapers and from the participant pool of the Life-Management Laboratory at the University of Zurich. The sample consisted of a total of $N = 107$ adults, with $n = 37$ young adults (19–29 years, $M = 24.22$, $SD = 2.67$; 64.9% female), $n = 34$ middle-aged adults (38–51 years, $M = 44.09$, $SD = 3.65$; 76.5% female), and $n = 37$ older adults (58–73 years, $M = 66.46$, $SD = 4.49$; 75.7% female). Regarding education, 51.4% of the young adults, 16.5% of the middle-aged, and 24.3% of the older adults reported to hold the equivalent to a high school degree in the U.S.A.; 27% of the young adults, 38.2% of the middle-aged, and

18.9% of the older adults reported to hold a college or university degree; 16.2% of the young adults, 44.1% of the middle-aged adults, and 45.9% of the older adults reported to have finished an apprenticeship or an equivalent diploma; and 5% of the younger, none of the middle-aged adults, and 10.8% of the older adults had finished their education with the 10 years of school obligatory in Switzerland.

The majority of the older adults (93.8%), but none of the participants in the other age groups were retired, 70.3% of the middle-aged adults worked part- or full-time, 96% of the young and 11.8% of the middle-aged adults were students or in vocational training.

Task. We developed a complex task encompassing two interdependent parameters: (1) an indicator of personal financial gain and (2) an indicator of the ecological state. Participants were asked to imagine that they were given an apple orchard for 20 harvest seasons. After each season, all of the apples would be sold, which would translate directly into financial gain. This was the basis for the payment of participants at the end of the experiment. The task was set up in such a way that the yield (tons of apples harvested in each season) was based on the following parameters: (a) The ecological state of the orchard (strength of soil and trees) and (b) the number of insects. Insects attack apples (more insects result in a lower yield), but they also enrich the soil, which increases the strength of the trees and, in subsequent seasons, the yield. Hence, a higher number of insects help maintain the ecology, which is linked to a higher yield in subsequent seasons, but to a lower yield in the current season. Pheromones could be sprayed that repel (but not kill) insects. Thereby, indirectly, spraying pheromones – by reducing the number of insects – increases the immediate yield, but also weakens the soil and hence threatens the ecological state of the apple orchard. All of this was explained to

the participants. To make sure that they understood the task, we asked the participants multiple-choice comprehension questions after they had been instructed and provided feedback until all of their responses to the comprehension questions were correct.

Given the task-inherent difference in immediate and delayed consequences of spraying pheromones, we expected young adults in particular to increase the use of pheromones in the last trials of the experiment, thereby increasing their personal profit while weakening the ecological state of the apple orchard. Older adults, in contrast, were expected to improve the ecological state of the apple orchard across the course of the experiment by using pheromones in moderation, thereby obtaining a lower yield (and payment). Assuming continuous adult developmental trajectories, middle-aged adults were expected to fall between the other two groups as they were expected to endorse generative goals while still wanting to maximize their personal gain (Ebner et al., 2006).

The task was computerized (using MediaLab by Jarvis, 2004). In each trial, participants typed in how much spray (in liters) they wanted to use to fight off the insects. Note that 20 harvesting seasons included 19 rounds of deciding upon the amount of pheromones sprayed. After each trial, participants were shown the yield (in tons) and the ecological state of the apple orchard (on an arbitrary scale with only the maximum specified at a score of 1000). On the behavioral level, the central dependent variable was the use of pheromones across trials as an indicator of the strategy used to choose between improving the ecological state of the apple orchard and increasing one's own financial gain from the yield. On the outcome level, the two additional dependent variables were (1) the financial gains across trials and (2) the ecological state of the apple orchard across

trials. Financial gains and the ecological state of the orchard were moderately negatively correlated ($r = -.22, p = .02$).

Given how the task was set up, we expected all participants to need a certain amount of trials at the beginning of the experiment to find out how variation in the different parameters affects the environmental state of the apple orchard and the yield. Thus, we expected to observe a steep learning curve for all three age groups with respect to the yield and the ecological state of the orchard. Age-related differences in strategy (i.e., amount of pheromones sprayed) and the resulting effects on the yield and the ecological state of the orchard were expected to emerge in the second and third part of the experiment. We expected older adults to adjust the amount of pheromones to optimize the ecological state and younger adults to optimize the yield and, thereby, their personal financial gains. Middle-aged adults were expected to fall somewhere in between. We expected this to result in a main effect of trial on the three dependent variables (indicating the learning curve at the beginning) and an age by trial interaction.

Procedure. Participants were tested in small groups of up to four participants with an experimenter present who welcomed them and showed them to the computer. All instructions were presented on the computer. In order to avoid drawing participants' attention to the fact that we investigated age-related differences, we tested age-homogeneous groups. After obtaining informed consent, participants filled out a brief questionnaire concerning sociodemographic variables. They then received detailed instructions on how to perform the apple orchard task and worked on the task for 20 trials. At the end, participants were thanked, debriefed, and reimbursed with 10 Swiss francs (at that time equivalent to 10 USD). In addition, they received the amount of

money they had earned in the apple orchard task ($M = 8.14$ Swiss francs, $SD = 1.77$; there were no age-related differences in the amount of money participants earned in the task: $F(2, 105) < 1$, *ns*).

Results

To test our hypotheses, we conducted repeated measures analyses of variance across trials with the between-subject variable age group (young, middle-aged, older) for each of the three dependent variables: amount of pheromones sprayed, yield, and ecological state of the apple orchard. There were 19 trials for the behavioral measure of pheromones sprayed and 20 trials for the two outcomes yield and ecological state.

Use of pheromones. There was a significant main effect of trial ($F(1,105) = 10.53$, $p = .002$, $p\text{Eta}^2 = .09$) that was qualified by the expected interaction between age and trial ($F(2,105) = 6.61$, $p < .001$, $p\text{Eta}^2 = .11$). Figure 1 seems to suggest that this interaction is due to young adults spraying more and more pheromones in the last third of the experiment, whereas middle-aged adults used a moderate amount of pheromones throughout the experiment, and older adults gradually increased the amount of pheromones used. Follow-up analyses splitting the trials into three blocks of six to seven trials revealed a significant main effect of block ($F(1,105) = 9.53$, $p = .003$; $p\text{Eta}^2 = .08$) that was qualified by an interaction of age and block ($F(2, 105) = 5.55$, $p = .002$; $p\text{Eta}^2 = .11$). Figure 2 shows that young adults show a marked increase in spraying pheromones the third block of the experiment, but this is not the case for middle-aged and older adults.¹

Yield. The expected interaction between age (3 age groups) and trial (20 trials) evinced a trend ($F(2, 105) = 1.51$, $p = .086$; $p\text{Eta}^2 = .46$). There was general increase in

yield over the course of the 20 trials, which is reflected, in a main effect of trial ($F(1, 105) = 59.07, p < .001; p\eta^2 = .36$). There was no main effect of age ($F(2, 105) < 1, ns$), indicating that all age groups understood the task and were able to increase their yield.

The trajectories displayed in Figure 3 suggest that the trend interaction of age and trial might be due to young adults achieving higher yields in the last quarter of the task whereas middle-aged and older adults did not increase their yield very much after the fifth trial. Thus, we ran a follow-up analysis splitting the trials into one block containing the first five trials and one block with the remaining 15 trials. This analysis confirmed the above interpretation of the trend interaction of age by trial. Again, the main effect of time indicating that the yield increased over the course of the two blocks in the experiment ($F(1,105) = 87.20, p < .001; p\eta^2 = .45$) was qualified by an interaction between age and block ($F(1,105) = 3.15, p = .047; p\eta^2 = .06$). Figure 4 suggests that younger adults achieved a sharper increase in yield compared to middle-aged and older adults.

Ecological state of the orchard. The effect of the use of pheromones is reflected in a significant quadratic effect of the interaction between age and trial ($F(2, 105) = 3.18, p = .046, p\eta^2 = .06$). As can be seen in Figure 4, the ecological state of the orchard increased for all age groups until the middle of the experiment. For older adults, it continued to increase until the end of the experiment; for young adults, it dropped in the last three trials. For middle-aged adults, there was a steady but overall slower increase in their improving the ecological state of the orchard that led to their achieving the same result as the young adults by the end of the experiment. The main effect of trial was significant ($F(1, 105) = 37.03, p < .001$) but there was no main effect of age ($F(2, 105) < 1, ns$).²

Discussion

When having to balance monetary and ecological concerns in the same task, younger adults behaved in a way that continued to maximize their financial gains throughout the course of the task, whereas older adults' behavior optimized the ecological state. Consistent with our hypotheses, the main result of Study 2 was that the age groups differed markedly in how they solved the task across trials. At the beginning of the task, all three age groups showed clear learning effects concerning how to make monetary gains and how to manage the ecological state of the apple orchard. The differentiation between age groups started to show only after about a third of the trials, when participants seem to have learned about the effects of the amount of pheromones sprayed on the subsequent yields and the ecological state of the apple orchard. As expected, young adults continued to optimize their financial gain at the cost of the ecological state of the hypothetical orchard. This was particularly evident towards the end of the experiment when ecological harm could no longer translate into future monetary loss. In contrast and as hypothesized, despite the fact that it was merely a hypothetical orchard, older adults ended the experiment with an ecological state that was superior to that of the younger or middle-aged adults. Middle-aged adults fell between the other two age groups, which may indicate that they were oriented towards personal financial gain as well as preserving the ecological state of the orchard. Thus, although all age groups successfully learned how to manage the apple orchard and increase financial gain, a qualitative difference in task orientation was prominent between young and older adults. This difference could not be located to a specific part over the duration of the experiment. However, because the personal payment not only depended on the state of the apple

orchard at the end of the game but also accumulated over the course of the entire experiment, it is not crucial for our hypothesis exactly where in time the differences between age groups occurred.

Taken together, the results of Study 2 suggest that older adults show more altruistic behavior by optimizing the ecological state of the (hypothetical) apple orchard, whereas younger adults show a strategy that indicates a more self-centered behavior aimed at maximizing their actual financial gain.

Study 3: Age and donation behavior

Study 1 used self-reported values; Study 2 used a hypothetical orchard to investigate which values guide behavior when pitting altruistic (ecological) and self-centered (financial) concerns against each other. Fortunately, such an experiment does not have actual ecological consequences. Unfortunately, this also constrains the validity of the problem-solving task. Thus, Study 3 was conducted to complement Studies 1 and 2 by investigating actual donation behavior. In an online study, participants could either keep the money they had earned for participating in a previous, unrelated study, or donate it to a good cause (viz., Doctors Without Borders). We hypothesized that the higher level of altruism in older adults is expressed by a greater likelihood to donate their money than younger adults. Moreover, although we expected income to be positively related to the tendency to donate one's study reimbursement, we hypothesized that age is associated with donation behavior even when statistically controlling for income.

Method and Results

Participants were recruited from the participant pool of our laboratory. After providing informed consent, participants completed a 15-minute online questionnaire

pertaining to an unrelated topic. As reimbursement, participants could choose between receiving an Amazon voucher worth five Swiss francs (at that time corresponding to 5 USD) or donating the same amount to a charitable organization (viz., Doctors Without Borders). The option chosen was assessed and used as a dependent variable indicating whether participants used the reimbursement to buy something for themselves (Amazon voucher) or donated it to a good cause.

Sample. In this study, 25 of the 129 participants did not provide data regarding their income or choice between an Amazon voucher and a donation. The final sample consisted of $N = 103$ young, middle-aged, and older adults (age range: 18-85 yrs, $M = 43.97$, $SD = 18.6$; 70.9% female). Across the four categories of self-reported gross monthly household income, income was distributed as follows: (a) < 2,000 Swiss francs: 25.2%, (b) < 5,000 Swiss francs: 34%, (c) < 10,000 Swiss francs: 30.1%, (d) 10,000 Swiss francs or more: 10.6%. Age and income were positively correlated, $r = .47$, $p < .001$. Thus, income will be controlled for in the subsequent analyses.

Results. The choices between making a donation (52.4%) and opting for an Amazon voucher (47.6%) were fairly equally distributed. The results of a stepwise logistic regression with the choice between donating the money or keeping it for oneself as the dependent variable revealed that income, entered at Step 1, was significantly related to donation behavior ($\text{Chi}^2 (df = 4) = 19.24$, $p = .001$), with only the second income category (< 5,000 Swiss francs) showing a significant negative effect on donation behavior (Wald = 6.21, $p = .01$). Entering age in the second step significantly contributed to the prediction of donation behavior (Wald = 17.11, $p < .001$; $\text{Chi}^2 (df = 1) = 23.47$, $p < .001$; omnibus test of model $\text{Chi}^2 (df = 5) = 42.71$, $p < .001$; Nagelkerke $R^2 = .44$), with

none of the income categories remaining significant.³ Thus, in this study, the age-related differences in income did not affect the positive relationship between age and donation behavior.

Discussion

Study 3 investigated whether age is related to altruistic behavior, operationalized as donating money to a good cause. Younger, middle-aged, and older adults had earned the money by filling out short questionnaires on topics unrelated to materialistic and altruistic values. With increasing age, adults were more likely to donate money to a good cause (*viz.*, Doctors Without Borders) than to keep it. Importantly, although age was correlated with income, the effect of age on donation behavior was stable when we controlled for income. This suggests that the age-related increase in altruistic behavior is not simply due to the fact that older adults can afford to donate money and younger adults cannot.

One limitation of Study 3 is that the alternative to donating the five Swiss francs was to receive an Amazon voucher for five Swiss francs. One might argue that the voucher was less attractive than donating the money as it required additional effort on the part of the participants (*i.e.*, visiting the Amazon website and searching for a product one would like to purchase). Although this applies equally to all age groups, one could argue that older adults might have been particularly reluctant to invest time and effort in this additional step and simply chose the less demanding alternative. However, Study 3 was an online study, which makes it highly unlikely that older adults would shy away from online transactions more than younger or middle-aged adults would. One could also argue that five francs is a small amount of money and that it hardly matters to older adults

whether they keep such a small amount of money for themselves or donate it. However, note that the amount is equally small to younger age groups. (As a standard of comparison: At the time of testing a “McDonald’s Big Mac” cost 6.50 francs in Switzerland.) Thus, five francs was a small amount of money for the students as well. Moreover, keep in mind that we controlled for income in our analyses, thus keeping age-related differences in income level stable when we tested the effect of age on donation behavior. Nevertheless, to address whether additional effort related to the Amazon voucher and/or the small amount of money might have caused the positive association between age and donation behavior, Study 4 (a) doubled the amount of money that could be earned and (b) offered the alternative options of immediately receiving the money in cash versus donating it.

Study 4: Donation behavior and future time perspective

Another rationale for conducting Study 4 was to test the shortening of future time perspective as a factor that might contribute to increased altruistic behavior in older adults. Whereas socioemotional selectivity theory suggests that a shorter future time perspective should motivate to choose immediate over delayed rewards (Carstensen et al., 1999), Brandtstädter and colleagues (2010) proposed that a shorter future time perspective should increase ego-transcending values such as altruism. Lang and Carstensen (2002) have demonstrated a strong correlation between chronological age and time perspective. Thus, age-related differences in the tendency to behave altruistically such as donating money to a good cause might be driven by age-related differences in future time perspective.

Hence, Study 4 experimentally manipulated future time perspective and assessed subsequent donation behavior. Unlike Brandtstädter and colleagues, we manipulated time perspective by asking participants to describe what they would be doing the next day (short future time perspective) or what they would be doing in ten years (long future time perspective). We used this manipulation, which was developed by Ritter and Freund (2006), rather than reminding people of their mortality (as was done by Brandtstädter et al., 2010) because research on terror management theory has repeatedly shown that reminders of one's death increase ego-transcendent values in younger adults (Pyszczynski et al., 1999), but not in older adults (Maxfield et al., 2007). This pattern of results makes it unlikely that the adult age-related differences in altruism are due to a higher mortality salience in older adults. Therefore, in Study 4, we manipulated future time perspective, but not mortality salience. We used an experimental design inducing a short versus longer time perspective in younger, middle-aged, and older adults. As a dependent variable, we again used participants' decision to either donate the money earned in an unrelated experiment to a good cause or to receive the same amount in cash. This design allowed us to test the hypothesis that the effect of age on altruistic behavior is due to future time perspective.

Method

Study 4 used a sample that was recruited for an unrelated study on developmental expectations. The sample was recruited from the participant pool of the Life-Management Laboratory at the University of Zurich. After completion of an unrelated study, participants were asked to answer the time perspective question. Directly afterwards, they were reimbursed with 10 Swiss francs (at that time, equivalent to 10 USD) and were

asked to choose whether they wanted to receive their reimbursement immediately in cash or donate it to a good cause (viz., Doctors Without Borders). Decisions were made in a way that participants were alone in the room for this part of the experiment and could either leave the envelope containing the money in a box or take it with them.

Procedure. After providing informed consent, participants took part in an experiment on subjective evaluations of developmental trajectories in various life domains that took place in individual sessions in the laboratory and took about 30 minutes to complete. Sociodemographic variables including age, gender, and income were also assessed in this part of the study. Participants were then randomly assigned to the short or long future time perspective condition. After the manipulation, participants chose between keeping the 10 Swiss francs in cash for themselves and donating the money. Before leaving, participants were fully debriefed.

Manipulation of time perspective. Participants were randomly assigned to either the short or the long future time perspective condition. Short versus longer time perspective was induced by asking participants to describe what they would be doing on a typical day (a) tomorrow (short future time perspective) or (b) in 5 to 10 years (long future time perspective). Ritter and Freund (2006) developed this manipulation and tested its effectiveness; a manipulation check in the present study was thus unnecessary.

Sample. One person had to be excluded because of reporting an age of zero years, resulting in a sample of $N = 172$ adults aged between 18 and 84 years. As analyses of variance were chosen for testing the effect of the manipulation, we grouped the sample into young ($n = 48$, 18–29 years, $M = 24.1$, $SD = 2.89$; 50% female), middle-aged ($n =$

55, 30–53 years, $M = 44.22$, $SD = 7.4$; 63.6% female), and older adults ($n = 69$, 56–84 years, $M = 68.8$, $SD = 6.5$; 60.9% female).

Study 4 used the same income categories as Study 3, with the following frequencies for each of the age groups: (a) < 2,000 Swiss francs: young = 75%, middle-aged = 7.3%, older = 4.3%, (b) < 5,000 Swiss francs: young = 14.6%, middle-aged = 18.2%, older = 33.3%, (c) < 10,000 Swiss francs: young = 8.3%, middle-aged = 45.5%, older = 37.7%, (d) 10,000 Swiss francs or more: young = 2.1%, middle-aged = 29.1%, older = 24.6%. Age and income were again positively correlated with $r = .49$ ($p < .001$). Thus, income was controlled in the subsequent analyses.

Results

About half of the sample (48.6%) chose to donate their study reimbursement to a good cause. How was donation behavior related to age and time perspective manipulation? To address this question, we ran a logistic regression with the choice between donating the money and keeping it for oneself as the dependent variable and time perspective manipulation, age group, and income as well as the interaction between time perspective manipulation and age group as independent variables. The omnibus test was significant, $\text{Chi}^2(6) = 19.38$, $p < .01$, Nagelkerke $R^2 = .15$. Age group emerged as the only significant predictor of donation behavior, $B = .71$, $SE = .33$, $p = .03$. As can also be seen in Table 1, being older was associated with a higher likelihood of donating money.

Manipulation of time perspective did not contribute significantly to the prediction of donation behavior, $B = -1.1$, $SE = .93$, $p = .23$, nor did income, all $ps > .15$. There was a marginally significant interaction between manipulated time perspective and age group, $B = -.73$, $SE = .41$, $p = .075$. As a follow-up analysis of this interaction effect, we ran

cross-tabulations of manipulated time perspective and donation behavior for each of the age groups separately. While there was no significant association between manipulated time perspective and donation behavior in younger, $\text{Chi}^2(1) = 0.35, ns$, or middle-aged adults, $\text{Chi}^2(1) = 0.15, ns$, the association was significant in the group of older adults, $\text{Chi}^2(1) = 4.25, p = .05$. As can be seen in Table 1, in contrast to the older adults in the short time perspective condition, the older adults in the long time perspective condition did not show a greater likelihood to donate money than to keep it. It seems, then, that inducing a shorter future time perspective in younger or middle-aged adults does not make them more likely to make a donation, but inducing a long future time perspective in older adults makes them less likely to make a donation.

General Discussion

Taken together, the four studies presented in this article provide evidence supporting the hypothesis that altruism is positively related to age. Two forms of altruism were considered: ecological mindedness (i.e., caring for environment) and donations to a charity. The hypothesis that these forms of altruism are positively related to age was tested with a multi-method approach using self-report data from the Word Value Survey (Study 1), behavior in a complex decision task (Study 2), and actual donation behavior (Studies 3 and 4). Moreover, Study 4 attempted to address one of the factors that might contribute to the age-related differences uncovered in the present studies by manipulating time perspective in young, middle-aged, and older adults.

The main finding of the present studies is that, across the different methods and samples, older adults appear to be more altruistic according to their self-reports, their problem-solving behavior, as well as their donation behavior (rather than keeping the

money for themselves). This effect is independent of income. Although each of the individual studies has certain weaknesses and allows alternative interpretations, taken together they provide a very consistent pattern of results that, as a whole, supports the hypothesis of an age-related increase in altruism defined as contributing to the public good.

The current findings support Erikson's (1986) notion of age-related differences in generativity. However, different to Erikson's stage theoretical assumptions, the results of the current studies suggest that environmental concerns, one form of generativity, seems to show an age-related increase beyond middle adulthood and extend into old age. These age-related differences were evident both in self-reported ecological concerns (Study 1) as well as in behavior in a complex problem-solving task (Study 2) and actual donation behavior (Studies 3 and 4). Different to previous studies that found generativity-related behaviors to decrease with age (McAdams, de St. Aubin, & Logan, 1993; McAdams, Diamond, de St. Aubin, & Mansfield, 1997) the current studies ensured that all age groups had the same opportunity to exhibit altruistic behavior. Thus, previous research might have underestimated the willingness to behave generatively (or altruistically) in old adulthood because they did not take the opportunities into account to display such behaviors.

The main limitation of the current studies is that they used cross-sectional designs comparing adults of different ages. Moreover, all the studies were conducted within one culture and at one historical time, and are thus unable to address the question of potential historical changes or cultural differences in age-related differences in altruism. As is true for all cross-sectional studies, the present studies cannot disentangle the effects of

historical period, cohort, and age. Regarding cohort-related differences, it might be that older cohorts were socialized in a way that stressed the importance of contributing to the public good and that younger cohorts are more selfishly focused on their personal gain. Consistent with a developmental (rather than a cohort) interpretation of the age-related differences found in our studies, Midlarsky and Hannah (1989) reported over two decades ago that donations to a good cause were positively related to chronological age. As our data were collected over 23 years later and age-related associations with donation behavior were maintained, it is likely that they do not simply reflect cohort-related associations. However, this is only indirect support and does not provide a definitive answer to the question of cohort versus age-related effects. More directly related to the question of value change across generations, a study by Inglehart (2008) compared changes in self-reported values by comparing different cohorts. Across cohorts, he found that cohorts seem to become less oriented towards materialistic values that emphasize economic and physical security. On the basis of this finding, one could argue that cohort-related differences in values run counter to the age-related effects found in the present studies.

The ideal way to address the question of the relative impact of cohort and age involves cross-sequential studies following different cohorts over longer periods of time. Unfortunately, such a study would take many decades as the samples span more than 50 years of age. Before such data are available, it seems prudent to make use of cross-sectional designs, but to keep the problems associated with cross-sectional designs in mind when interpreting the data.

Values such as altruism and related behaviors are likely to vary not only as a function of age but also by culture. The current set of studies focused on age but leaves open the question of cultural variations and potential interactions of age and culture. A theoretical framework embedding the study of age-related differences in the study of culture is currently still lacking and, to our knowledge, as of yet there exist no studies comparing altruism in different age groups across different cultures. Hopefully, the current set of studies will inspire such research.

Returning to the results of the present studies, Study 1 provided evidence for a positive association of age and the endorsement of the ecological value of caring for the environment and a negative association of age and the endorsement of the self-centered value of being rich in a fairly large sample of Swiss adults aged 18 to 89 years. The pattern of results was the same for the U.S. American sample that participated in the World Values Survey. Although effect sizes were small for both samples, they were maintained after controlling for self-reported income. It would be interesting to systematically explore possible cultural differences in age-related differences in the endorsement of materialistic vs. environmental values. This question was beyond the scope of the paper. Moreover, currently there does not exist an overarching theoretical background specifying the factors that might shape aging differentially in different cultures.

One limitation of Study 1 is that it relies exclusively on self-report and single items assessing the respective values. This shortcoming was addressed in Study 2, which assessed behavior displayed in a complex problem-solving task across 20 trials. In this task, participants were to consider monetary and ecological concerns simultaneously. At

the beginning of the task, all three age groups showed clear learning effects concerning how to make monetary gains and how to manage the ecological state of a hypothetical apple orchard. This indicates that all of the age groups understood the task and learned how their actions affected the ecological and monetary outcomes. The differentiation between age groups started to show only after about a third of the trials when people seemed to have learned about the effects of the amount of pheromones sprayed on the subsequent yields and the ecological state of the apple orchard. During the latter part of the experiment, young adults optimized their financial gain at the cost of the ecological state of the hypothetical orchard. In contrast, despite the fact that it was merely a hypothetical orchard, older adults optimized the ecological state of the apple orchard. Middle-aged adults fell between these two age groups, which might indicate that they were oriented towards increasing personal financial gain as well as improving the ecological state of the orchard. The older adults' behavior can be interpreted as being altruistic (i.e., caring for the environment), whereas the younger adults' behavior can be interpreted as being self-serving (i.e., aimed at maximizing their personal gain at the cost of the ecological state of the hypothetical orchard).

The complex problem required people to make multiple decisions over the course of the task so that behavior could be observed over time. This not only provides more reliable data than a single snapshot at one point in time, it also goes beyond the self-report in Study 1 in that people actually make a series of behavioral decisions that have visible consequences: The amount of apples harvested translated directly into the participants' actual payments, and feedback regarding the ecological state of the orchard was provided after each harvesting season. Nevertheless, the altruistic behavior

concerned a hypothetical rather than an actual apple orchard. Thus, Studies 3 and 4 addressed the question of adult age-related differences in an actual decision to keep money for oneself or to donate it to a charitable cause, another act of altruism.

Confirming our interpretation of Studies 1 and 2, older adults were more likely to donate the money they had previously earned as reimbursement for study participation to charity than younger and middle-aged adults. This effect was not simply due to the positive relationship between income and age: Income contributed very little to donation behavior and, more importantly, age effects were significant after controlling for income.

One of the factors potentially underlying age-related differences in altruistic value orientation suggested by Brandstädter and colleagues (2010) and also playing a dominant role in SST (Carstensen et al., 1999) is future time perspective (see Ritter & Freund, in press). SST suggests that the shorter future time perspective should lead to a stronger focus on the here and now. This could be interpreted as leading to stronger hedonic and self-centered goals and values. In contrast, Brandstädter and colleagues argue that the shorter future time perspective prevalent in old age should lead to a stronger endorsement of ego-transcending values. Following Brandstädter's rationale, we manipulated future time perspective in Study 4 to test whether inducing a shorter time perspective might increase younger adults' donation behavior and, vice versa, whether inducing a longer time perspective in older adults might decrease their donation behavior. Results supported only the second part of the hypothesis: Older adults who adopted a long time perspective did not show the same inclination as older adults who adopted a short time perspective to donate their money to a good cause. It seems, then, that a longer time perspective might make older adults more selfish, but a shorter time perspective does not

make younger adults more altruistic. A long future time perspective might activate self-centered financial concerns that might outweigh altruistic motives. In contrast, a short time perspective does not seem to trigger “warm glow” altruism that leads to immediate gratification by making altruistic people feel good about themselves and their behavior. Note that not finding full support for the original hypothesis in one study, however, does not imply that the hypothesis should be entirely abandoned. More studies are required to do so and future studies should try to manipulate time perspective in different ways and use different indicators of altruism.

Another possibility for decreased materialism in older adulthood might be that older people might not want to amass more material belongings because they might be at a point in their lives when acquiring more belongings becomes a burden rather than a resource. Finances need to be managed and acquiring more things might run counter the wish to downsize for a move into a smaller house or apartment. In contrast, donating to a good cause and thereby helping those in need often does not require commitment for future investments that older people might not want to make.

Future studies are needed to investigate other candidates for factors underlying the age-related differences found in the present studies, such as the need to achieve certain developmental tasks (e.g., establishing oneself professionally, founding a family), before people’s focus can move from the accumulation of resources for themselves towards altruism.

Conclusion

In conclusion, the findings of the current studies suggest that older adults tend to report higher altruism and behave in more altruistic ways. Altruism is a complex

construct that needs to be approached from different angles. Only by accumulating evidence across different aspects of altruism and by using different methods, the current findings provide convincing support of the general hypothesis that older adults become more altruistic. In this paper, we adopted the definition of altruism as contributing to the common good: In Studies 1 and 2, the common good was operationalized as caring for the ecology. In order to not only assess ecological-mindedness but also to actually tap into the broader construct altruism, Studies 3 and 4 assessed contributing to the common good as donating to a good cause. The common thread of all of these studies is the examination of age-related differences in altruism using different methodological approaches ranging from self-report to behavior in a complex problem-solving task and actual donation behavior. This multi-methodological approach makes less likely that each individual study uses a dependent measure that shows age-related differences that are specific to this measure. In sum, then, considered together the current studies suggest that, spanning different aspects of altruism and across different methodological approaches, across adulthood age is positively associated with altruism.

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Footnotes

¹ Note that further follow-up analyses within the three blocks did not evince significant age-related differences (all $p > .17$), which is likely due to the reduced statistical power to detect differences between age groups using a truncated numbers of trials.

² To test if gender or educational background might affect the results, we re-ran all of the analyses of Study 2 with these two variables as covariates. Neither gender nor education showed any significant effect on the outcomes.

Table 1.

Study 4: Donation behavior by age group and manipulation of time perspective (absolute numbers and percentage within each age group)

Age group	Time Perspective	Donation	Keep money
Young	Short	7 (14.3%)	19 (38.8%)
	Long	8 (16.3%)	15 (30.6%)
	<i>Total</i>	<i>15 (30.6%)</i>	<i>34 (69.4%)</i>
Middle-aged	Short	16 (29.1%)	14 (25.5%)
	Long	12 (21.8%)	13 (23.6%)
	<i>Total</i>	<i>28 (50.9%)</i>	<i>27 (49.1%)</i>
Older	Short	25 (36.2%)	10 (14.5%)
	Long	16 (23.2%)	18 (26.1%)
	<i>Total</i>	<i>42 (59.4%)</i>	<i>28 (40.6%)</i>

Figure 1. Results of Study 2. Amount of pheromones across trials by age group.

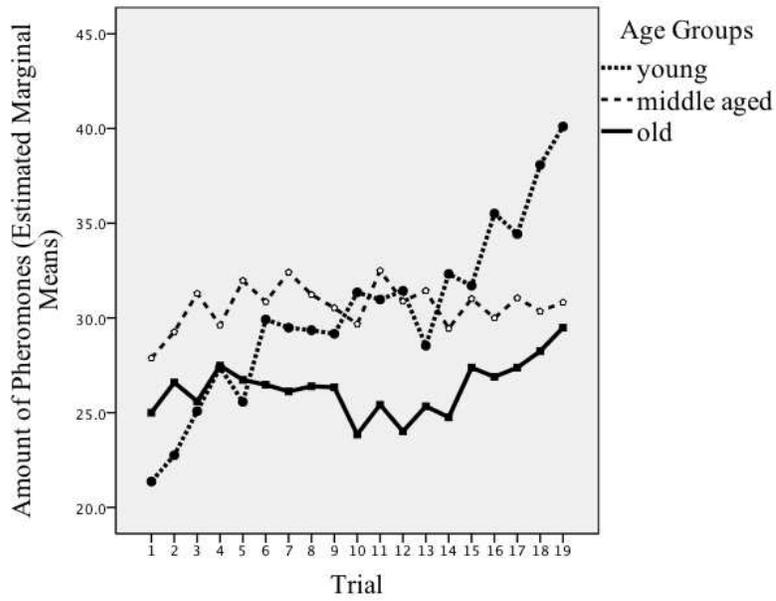


Figure 2. Results of Study 2. Amount of pheromones across first, second, and third block of grouped trials by age group.

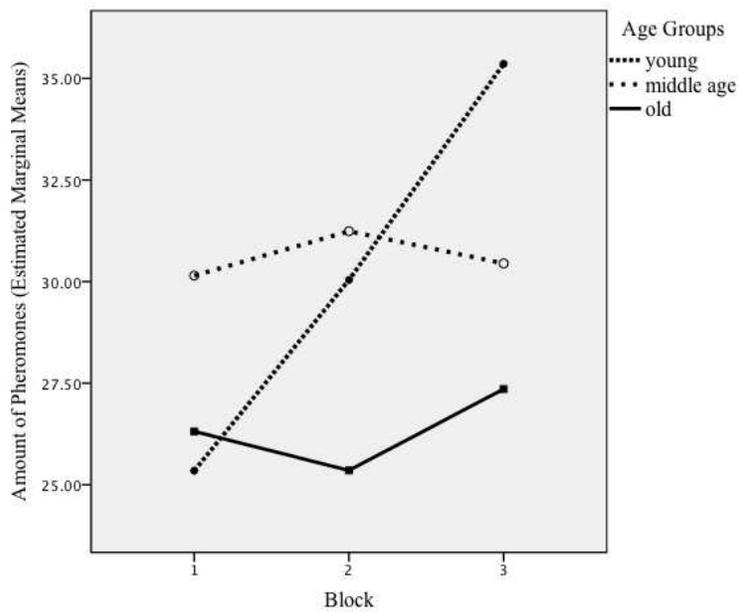


Figure 3: Results of Study 2. Yield (tons of apples) across trials by age group.

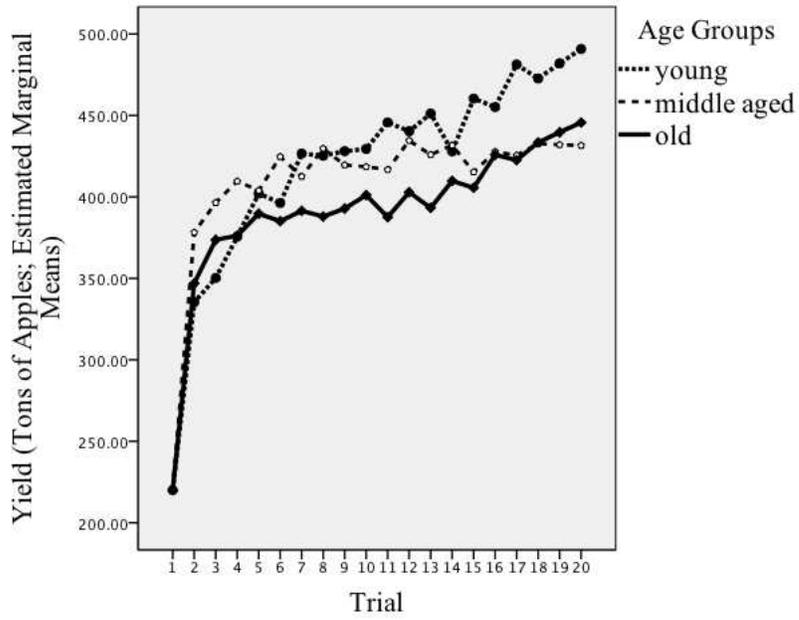


Figure 4: Results of Study 2. Amount of apples yielded in the first quarter of the experiment (block 1) and the remaining three quarters (block 2) by age group.

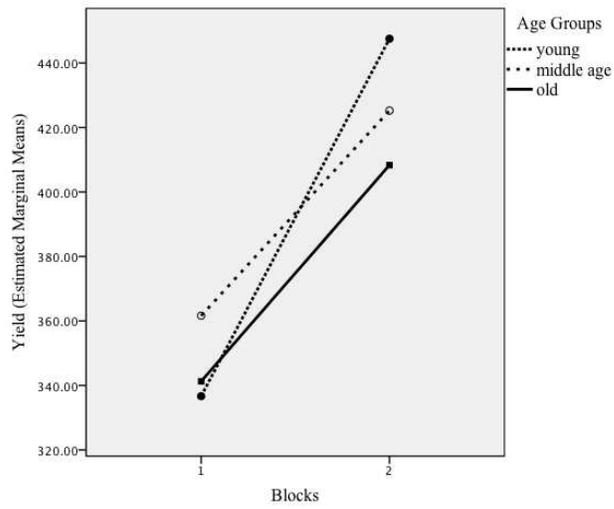


Figure 4: Ecological state of the orchard across trials by age group.

