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Age-related changes and gender differences in time estimation

Lourdes Espinosa-Fernández [a,*], Elena Miró [b], MóCarmen Cano [a], Gualberto Buela-Casal [b]

[a] Department of Psychology, University of Jaén, Campus Las Lagunillas, 23071 Jaén, Spain
[b] Department of Personality, Evaluation and Psychological Treatment, University of Granada, Spain

Abstract

A study was carried out in which age and gender differences were studied in the performance of an empty interval production task. The duration of these intervals was 10 s, 1 and 5 min. The sample was made up of 140 subjects, half male and half female, in seven different age groups from 8 to 70 years old. The age range permitted us to identify when differences begin to be significant. The results show an age-related increase in the underproduction of the intervals. The differences between age groups attained significance from 51 to 60 years onward. With regard to gender, the main result was a greater underproduction of longer intervals (1 and 5 min) for women. These findings were interpreted in terms of different models of time estimation.

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1. Introduction

The interest in studying the way living beings experience the passing of time is not something new. Many studies exist in which the importance of this subject has been clearly established. Perception and time estimation are considered relevant control mechanisms in the behaviour of organisms. Timing of durations ranging from

* Corresponding author. Tel.: +953-002663; fax: +953-012197.
E-mail address: lespino@ujaen.es (L. Espinosa-Fernández).

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seconds to minutes is essential for representing the immediate external environment (Block, Zakay, & Hancock, 1998). This is evident in many daily situations, for example, while driving down or crossing a busy street, speed and time estimates are continually required. While waiting at the bus stop or accessing a specific web page a feeling of lengthened duration may influence whether a person continues to wait or returns on a subsequent visit. A person may use a duration judgement to decide whether to continue trying to solve a problem or to quit. Because many everyday perceptual and cognitive situations lead a person to estimate short durations it is important to understand the underlying processes and whether or not individual differences exist within these processes (Block, Hancock, & Zakay, 2000).

One important source of individual differences between people is age. In relation to time perception and estimation one experience that is often described by a large number of people is the age-related change in velocity of the passing of time. It is as though, with the passing of the years, physical time passes more quickly, demonstrating a lack of adjustment or synchronization between the speed of physical time and subjective or "internal" time (Fraisse, 1984; Schroots & Birren, 1990). This subjective experience has been the object of study in various investigations in which different methodological approaches have been used. Some studies employed questionnaires in which the participants were asked if they perceived any change in relation to the speed in the passing of time with respect to earlier ages. Similarly they could have been asked about the time which had elapsed since the occurrence of a significant event until the present moment (Joubert, 1984; Lemlich, 1975; Walker, 1977). On the other hand, other studies employed situations of reproduction, verbal estimation or production of time intervals, these intervals being variables in terms of duration or in terms of the stimulus presented during them (Craik & Hay, 1999; Eisler & Eisler, 1992; Marmaras, Vassilakis, & Dounias, 1995). In both types of studies, the basic finding is that physical time passes more quickly than subjective time. However, changes have also been found in the opposite direction. In fact, in a meta-analytic review (Block et al., 1998), it is found that compared with younger adults, older adults gave larger verbal estimates and made shorter productions, although they made comparable reproductions. This suggests that the specific findings are critically dependent on the type and design of the study and the methodology employed (for a review see Block & Zakay, 1997; Marmaras et al., 1995). This makes it difficult to extract conclusions from the different studies and even more so if they do not adequately describe the exact methods used (Block et al., 1998; Hicks, Miller, & Kinsbourne, 1976; Zakay, 1993).

Another important variable contributing to individual differences in the estimation of time is gender. The research about differences related to gender in duration judgements began a century ago (MacDougall, 1904; Seashore, 1899; Yerkes & Urban, 1906). The results in relation to gender are quite confusing. Whereas some studies have found significant differences between men and women in different time estimation tasks (Bell, 1972; Delay & Richardson, 1981; Eisler & Eisler, 1992; Hancock, Vercruyssen, & Rodenberg, 1992; Rammsayer & Lustnauer, 1989), others have not (Geer, Platt, & Singer, 1964; Marmaras et al., 1995; Roeckelein, 1972). Where differences were found between men and women, the general result has been greater precision and less variability in estimations of men (Block et al., 2000; Roeckelein, 1972). This result has been found using the repeated production method (Bell, 1972), the comparison method (Rammsayer & Lustnauer, 1989) and the reproduction method (Eisler & Eisler, 1992; Rammsayer, 1998). To be specific, with regard to precision, the result most frequently found was a greater overestimation in time intervals in the group of women when the verbal estimation method was used and/or a greater underproduction when the production method was used (Kirkcaldy, 1984). It should be remembered that there is an inverse relation between these two methods (Bindra & Waksberg, 1956; Zakay, 1990). It is essential to point out that in some earlier studies, the time estimation task was performed in conditions in which other variables were manipulated, such as the intensity of sound or light which defined the intervals whose duration had to be estimated (see Hancock, Arthur, Chrysler, & Lee, 1994).

A recent meta-analytic review (Block et al., 2000) indicated that gender effects on time estimation vary with the type of paradigm employed (prospective versus retrospective). Prospective situations are those in which the individuals are conscious, before beginning the task, that they have to pay attention to the passing of time. Instead in retrospective situations, participants do not know until after a time period that they are being asked to judge its duration. In the prospective paradigm the number of trials, the participants' age and the duration judgement method are relevant variables. On the other hand, in the retrospective paradigm the number of stimulus presented during the target duration, the complexity of the stimuli, and the delay between the target duration and the judgement are the most important factors.

Unfortunately, studies systematically examining the effects of age and gender on time estimation are lacking. The possible existence of an interaction between age and gender could explain some of the inconsistent findings in time estimation literature. In fact, the meta-analytic review by Block et al. (2000) suggested such an interaction. Specifically, in prospective situations the differences in time estimation vary according to the subjects' age. It seems that gender effects are absent during adolescence or young adulthood, but there seem to be gender differences for both younger and older age groups. The interval productions are shorter for boys than girls and, in contrast, productions are shorter for older adult women than older adult men.

The focus of the present study is on the interaction between age and gender in a time estimation task. The method used here is production, in which the subject must produce a time interval which is verbally established by the experimenter (Bindra & Waksberg, 1956). This method involves comparing a time interval with information stored in the memory concerning conventional duration units, such as seconds or minutes. The intervals produced were empty intervals of three different durations: 10 s, 1 and 5 min. The empty interval means that no activity was undertaken during the interval of the estimate.

The sample consisted of subjects belonging to seven different age groups between 8 and 70 years old. Moreover, each age group included an equal number of boys and girls or men and women. The design of the current study, allowed us to identify the precise onset of gender differences in time estimation.

2. Method

2.1. Subjects

The subjects were selected by using a structured interview elaborated by the experimenter. They were asked about regularity in sleep habits, use of psychotropic substances, age, sleep patterns and state of health. This interview was conducted one or several days before the experimental task. For children and young adolescents the interview took place in the presence of one of the parents. The subjects did not know exactly what would be required.

A sample of 140 healthy volunteers performed the time estimation task, 70 were boys/men and the other 70 girls/women. The age range was from 8 to 70 years old. The subjects were divided into seven age groups: 8–10, 11–20, 21–30, 31– 40, 41–50, 51–60, 61–70. Each group was made up of 20 subjects (10 boys/men and 10 girls/women), so that there was one man and one woman for each year of age. The only exception was the first group (8–10 years). This group was made up of 3 eight-year-old girls and 3 eight-year-old boys, 4 nine-year-old girls and 4 nine-year-old boys, 3 ten-year-old girls and 3 ten-year-old boys. The youngest children participating in this study were 8 years of age. According to Pouthas (1993), children below the age of 7 years had not yet learned how to use conventional durations units (seconds, minutes, and so on) in a reasonably accurate way.

2.2. Experimental task

All subjects performed their task between 11:00 a.m. and 13:00 p.m. in the presence of the same experimenter. The subject was seated on a chair in a noise shielded experimentation room and was asked to remove his/her wristwatch (if he/she was wearing one) which was placed out of the subject's sight. Next, he/she was given a chronometer (Casio HS-3 with precision of ±99.997685%; timing unit: 1/100 s), and was told exactly what to do. The specific instructions given were as follows: "With the chronometer face down, you have to estimate 10 s. To begin, you must press this button on the chronometer (he/she is shown which). From that moment you have to start estimating 10 s. When you think that the ten seconds are up, you must press the same button again to stop the chronometer. When you have stopped it, show me the face of the stopwatch so that I can note down the result, and remember you may never look at it." The method used is the production method in which no other task is performed simultaneously during the estimation period, and the subject receives no feedback at any point while performing the task.

Before beginning the task, several practice trials were done. Moreover the subjects were asked to place the finger used to operate the chronometer just above the button to avoid unwanted delays. After each estimation, the experimenter would tell him/her to repeat the task or to estimate a different time interval. All subjects made 25 estimates of 10 s, 3 estimates of 1 min and 1 estimate of 5 min. When he/she had to estimate intervals of 1 min, the subject was told the following: "Now, instead of 10 s, estimate 1 min" and for estimating 5 min, he/she was told: "Now, to finish, instead of estimating 1 min, estimate 5 min." The order and number of estimations was as follows: 10 estimations of 10 s, 1 estimation of 1 min, 5 estimations of 10 s, 1 estimation of 1 min, 10 estimations of 10 s, 1 estimation of 1 min, and finally, 1 estimation of 5 min. The number of attempts made for each interval was different given that it is very complicated to ask the subject to perform, in only one session, 25 time estimations of 1 min, which is even more difficult for 5 min estimations. The fact that the intervals are empty made this even more pressing.

3. Results

Analyses were performed on directional errors (i.e. the estimation made by each subject divided by the real time interval) (see Table 1). This error is also coined the

Table 1
Mean values and standard deviation (SD) of the directional error in the estimation of 10 s, 1 and 5 min in each one of the seven age groups; for women, men and the total group

Age (years)	Sex	Estimation 10 s	Estimation 1 min	Estimation 5 min
		Mean (SD)	Mean (SD)	Mean (SD)
8–10	Women	0.65 (0.35)	0.74 (0.37)	0.71 (0.26)
	Men	0.62 (0.17)	0.63 (0.20)	0.61 (0.23)
	Total group	0.64 (0.27)	0.69 (0.30)	0.66 (0.25)
	Women	0.90 (0.17)	0.90 (0.23)	0.87 (0.36)
11–20	Men	0.96 (0.24)	0.10 (0.23)	1.11 (0.33)
	Total group	0.95 (0.23)	0.95 (0.23)	0.99 (0.34)
	Women	0.87 (0.26)	0.77 (0.28)	0.89 (0.34)
21–30	Men	1.02 (0.19)	1.01 (0.16)	1.02 (0.11)
	Total group	0.95 (0.23)	0.89 (0.25)	0.95 (0.26)
	Women	0.83 (0.30)	0.75 (0.41)	0.77 (0.41)
31–40	Men	0.86 (0.25)	0.91 (0.25)	0.92 (0.21)
	Total group	0.86 (0.27)	0.83 (0.34)	0.85 (0.33)
	Women	0.88 (0.60)	0.61 (0.63)	0.66 (0.30)
41–50	Men	0.83 (0.19)	0.75 (0.20)	0.90 (0.16)
	Total group	0.85 (0.43)	0.68 (0.46)	0.78 (0.33)
	Women	0.91 (0.60)	0.57 (0.41)	0.62 (0.14)
51–60	Men	0.74 (0.44)	0.66 (0.51)	0.91 (0.54)
	Total group	0.82 (0.51)	0.62 (0.45)	0.34 (0.20)
	Women	1.38 (0.57)	0.42 (0.24)	0.34 (0.20)
61–70	Men	0.65 (0.41)	0.51 (0.33)	0.46 (0.26)
	Total group	1.04 (0.61)	0.46 (0.29)	0.46 (0.26)
	Women	0.92 (0.46)	0.68 (0.40)	0.69 (0.33)
Total	Men	0.82 (0.31)	0.79 (0.33)	0.87 (0.34)
	Total group	0.87 (0.40)	0.73 (0.37)	0.78 (0.34)

duration judgement ratio (i.e. the ratio of subjective-to-objective duration) (see Block et al., 2000, 1998, 1999). The directional errors were subjected to Manova with two factors: age (seven age groups) and gender (males and females) and three dependent variables (estimates of 10 s, 1 and 5 min intervals). In this analysis we found a significant effect of age, Wilks'Lambda, $\lambda(18, 351) = 4.63$, $p < 0.01$; gender, $\lambda(18, 124) = 9.09$, $p < 0.01$; and of the interaction between age and gender, $\lambda(18, 351) = 2.68$, $p < 0.01$.

Follow-up analyses were then done for each of the intervals. Finally, a regression analysis was done taking age as a predictor variable and each one of the time intervals as the aforementioned variables.

3.1. Estimation of 10 s

The ANOVA failed to yield significant main effects; age $F(6, 126) = 3.18$, $p = 0.06$; gender $F(1, 126) = 2.71$, $p = 0.1$. But the age by gender interaction was significant, $F(6, 126) = 3.36$, $p < 0.05$. This interaction was due to an significant difference between men and women in the oldest age group, $T(18) = 3.39$, $p < 0.01$, but not in the other age groups ($p > 0.05$). In this group (61–70 years old) men underproduced the interval of 10 s (mean value: 0.65) while women overproduced (mean value 1.38) (see Fig. 1b).

3.2. Estimation of 1 min

The ANOVA yielded only a significant effect of age group, $F(6, 126) = 4.99$, $p < 0.01$. The main effect of gender and the interaction between age and gender failed to reach an acceptable level of significance, $F(1, 126) = 3.16$, $p = 0.08$; $F(6, 126) = 0.49$, $p = 0.81$, respectively. A summary of post-hoc comparisons between age groups is presented in Table 2. Significant differences were found between group 2 and 6, $t = 0.33$, $p < 0.05$; group 2 and 7, $t = 0.49$, $p < 0.01$; group 3 and 7, $t = 0.43$, $p < 0.01$; and group 4 and 7, $t = 0.37$, $p < 0.01$. In all these groups, intervals were underproduced, especially in the last two age groups (see Fig. 1a and b).

3.3. Estimation of 5 min

The ANOVA yielded a significant main effect of age group, $F(6, 126) = 7.64$, $p < 0.01$ and gender, $F(1, 126) = 11.77$, $p < 0.01$. The interaction was not significant, $F(6, 126) = 1.02$, $p = 0.41$. Post-hoc comparisons between age groups were found between group 1 and 2, $t = -0.33$, $p < 0.05$; group 1 and 3, $t = -0.29$, $p < 0.05$; group 2 and 7, $t = 0.53$, $p < 0.01$; group 3 and 7, $t = 0.49$, $p < 0.01$; group 4 and 7, $t = 0.39$, $p < 0.01$; group 5 and 7, $t = 0.32$, $p < 0.05$; and between group 6 and 7, $t = 0.30$, $p < 0.05$. Like the 1 min interval, there was underproduction in all

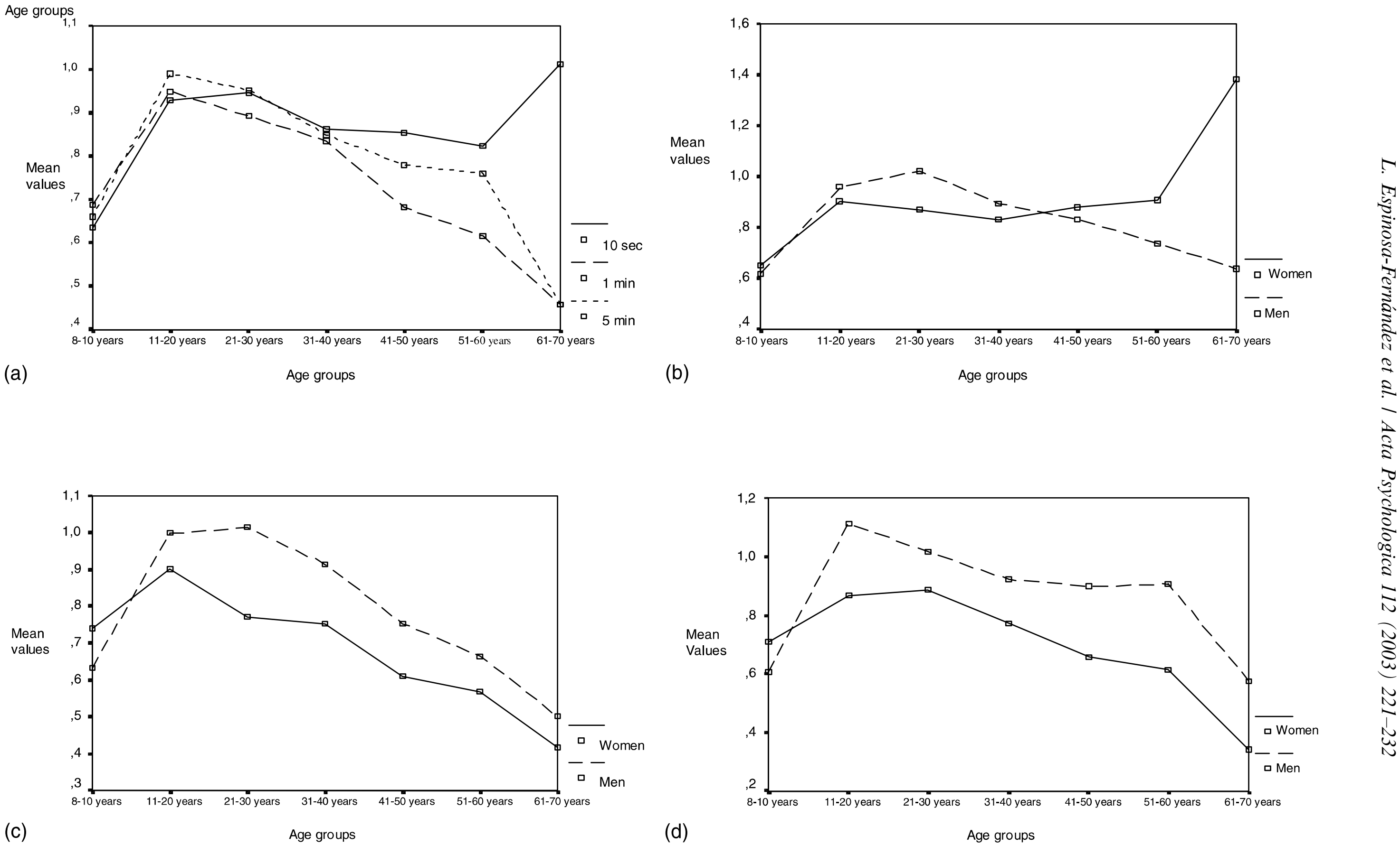

Fig. 1. (a) Mean values of directional error in the production of three time intervals (10 s, 1, 5 min) for the total sample. (b)–(d) Mean values of directional error in the production of the 10 s, 1 and 5 min intervals, respectively, for the group of women and men in the seven age groups.

Table 2
Results of the Tukeyś post-hoc analysis for the 1 and 5 min intervals

Comparisons	1 min		5 min	
	Differences	Mean	Differences	Mean
Group 1–2	−0.26	0.69–0.95	−0.33*	0.66–0.99
Group 1–3	−0.21	0.69–0.89	−0.29*	0.66–0.95
Group 1–4	−0.15	0.69–0.83	−0.19	0.66–0.85
Group 1–5	0.01	0.69–0.68	−0.12	0.66–0.78
Group 1–6	0.07	0.69–0.62	−0.10	0.66–0.76
Group 1–7	0.23	0.69–0.46	0.20	0.66–0.46
Group 2–3	0.05	0.95–0.89	0.04	0.99–0.95
Group 2–4	0.11	0.95–0.83	0.14	0.99–0.85
Group 2–5	0.27	0.95–0.68	0.21	0.99–0.78
Group 2–6	0.33	0.95–0.62	0.23	0.99–0.76
Group 2–7	0.49**	0.95–0.46	0.53**	0.99–0.46
Group 3–4	0.06	0.89–0.83	0.10	0.95–0.85
Group 3–5	0.21	0.89–0.68	0.17	0.95–0.78
Group 3–6	0.27	0.89–0.62	0.19	0.95–0.76
Group 3–7	0.43**	0.89–0.46	0.49**	0.95–0.46
Group 4–5	0.15	0.83–0.68	0.07	0.85–0.78
Group 4–6	0.22	0.83–0.62	0.08	0.85–0.76
Group 4–7	0.37**	0.83–0.46	0.39**	0.85–0.46
Group 5–6	0.06	0.68–0.62	0.02	0.77–0.76
Group 5–7	0.22	0.68–046	0.32*	0.77–0.45
Group 6–7	0.16	0.62–0.46	0.30*	0.76–0.45

* $p < 0.05$.
** $p < 0.01$.

these groups, especially in the last age group (see Fig. 1a and d). Women showed greater underproduction (mean = 0.69) than men (mean = 0.87).

3.4. Regression analysis

The linear regression coefficients were significant for age in the 1 min ($R^2 = 0.10$, standard error = 0.35, $p < 0.01$) and 5 min ($R^2 = 0.08$, standard error = 0.33, $p < 0.01$) for the total sample. The results show, moreover that with advancing age, there is marked underproduction of the 1 and 5 min intervals (see Fig. 1c and d). The regression analysis showed a significant linear coefficient in women for the 10 s intervals ($R^2 = 0.10$, standard error = 0.44, $p < 0.01$), 1 min ($R^2 = 0.12$, standard error = 0.38, $p < 0.01$), and 5 min ($R^2 = 0.17$, standard error = 0.30, $p < 0.01$). In men, the linear regression coefficient was significant only for the 1 min intervals ($R^2 = 0.09$, stand. error = 0.32, $p < 0.01$). These results demonstrate that in women, there is marked underproduction for the 1 and 5 min intervals with advancing age, whereas for the 10 s interval this relationship is inverted. The men tended to follow the general pattern of underproduction for all the intervalxs, although this effect was only significant for the 1 min interval. Finally, it should be noted that the regression coefficients did not significantly differentiate between men and women for any of the time intervals.

4. Discussion

The general trend found in the present study is the increase in the underproduction of intervals with advancing in age. All the age groups showed an underproduction, especially in age group 6 (51–60 years old) and group 7 (61–70 years). This age-related trend is in accordance with other studies reported in time estimation literature (Antequera, De Haro, Arroyo, & Blanco, 1994; Block et al., 1998). For example, Antequera et al. (1994) used a sample composed of 60 individuals with an average age of 76 years and found underproduction for an empty interval of 1 min. Block et al. (1998), in their review of age differences in time estimation, found greater underproduction in the group of elderly people (over 60 years of age) than in the group of young adults (18.0–29.9 years old). In another study, Carrasco, Bernal, and Redolat (2001), using the reproduction method, found that the reproductions of a 10 s interval were shorter in a group of very elderly men (mean age 79.1 years) than in a group of young men (mean age 26.15 years).

This increase in underproduction with advancing age is difficult to explain in terms of the internal clock. When we refer to the internal clock, we are really referring to a complex system, composed of various elements amongst which we find a pacemaker, an accumulator and a reference memory (Treisman, 1963, 1984). The pacemaker is the part of the system which is in charge of producing the pulses which are going to serve as the origin of information about time. The activity of this pacemaker may be influenced by physiological processes, such as the basal level of metabolism and/or the level of arousal. One of the effects or consequences of increasing age is precisely a decrease or slowing down of the internal and/or physiological processes within which is situated the speed of what is known as the internal clock. This deceleration of the internal clock in proportion to increase in age should have produced an overproduction instead of the underproduction that we observed.

Current research in the area of time perception and estimation suggest that theories of human duration judgement must take into consideration other more cognitive variables such as attention and memory, since only concentrating on terms of clocks or pacemakers is inadequate (Block, 1990; Friedman, 1990; Michon, 1990; Zakay & Block, 1996).

Thus, the attentional model claims that time estimation is determined or closely linked to the quantity of attention paid to the passing of time, which has received fundamental empirical support in prospective situations, such as that employed in this study (Brown, 1997; Hicks et al., 1976; Thomas & Weaver, 1975; Zakay & Shub, 1998). A cognitive clock or "timer" produces and codes temporal information. The more attentional resources allocated to the temporal task, the more pulses or units accumulated by the timer (e.g., Brown, 1985, 1997; Brown & Stubbs, 1992; Predebon, 1996). Possibly, with advancing age subjects pay less attention to the passing of time.

Along similar lines, it could be assumed that the performance of older subjects is simply a manifestation of what they are experiencing in their daily life which is that of time passes quickly (Fraisse, 1984; Schroots & Birren, 1990). This would be immediately in the bigger intervals, as it is in these intervals where the lack of adjustment between the passing of physical and subjective time is more evident. This would happen with increasing age, taking into consideration all the groups, but especially in group 7 (61–70 years old).

The results for gender showed a greater underproduction in women than in men, but only for the 5 min interval. This trend also appeared for the 1 min interval although no significant differences were found here. The tendency in women to underproduce has also been found in other studies (Block et al., 2000; Hancock et al., 1992, 1994; Kirkcaldy, 1984). The fact that differences were not found for all the time intervals used in the present study may be due to the fact that it is difficult to detect gender differences in psychological time (Block et al., 2000), or even in cognitive processes at large (Halpern, 2000).

For the 10 s interval the differences between men and women were only found for the oldest subjects (61–70 years old). Unlike the general tendency mentioned previously, women overproduced the 10 s interval. This finding is difficult to explain. We can offer only tentative explanations. One of these is that for this age group, menopause-related-hormonal changes may be involved. In fact, it is precisely around the age of 50 when these differences show up (see Fig. 1b). Another possible explanation may be related to gender differences in reaction time. It is well known that, in general, reaction times are greater in women than in men (Jurado, Luna-Villegas, & Buela-Casal, 1989) which could be exacerbated in the oldest age group and for the shortest time interval (10 s).

Finally, the current study showed that the differences between age groups become more apparent for longer intervals (5 min), while significant differences were only found in the most extreme groups (between group 1 and 7) for the short intervals (10 s). It should be noted, however, that in contrast to the other intervals there was only a single measurement of this interval (5 min). Consequently, the data must be considered prudently, although as we have verified, the direction of the results is similar to that found for the 1 min interval.

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