EXTRAVERSION/INTROVERSION AND AGE-RELATED DIFFERENCES IN SPEED-ACCURACY TRADEOFF

DIFERENÇAS DE EXTROVERSÃO/INTROVERSÃO E IDADE NA TROCA VELOCIDADE-PRECISÃO

DIFERENCIAS DE EXTROVERSIÓN/INTROVERSIÓN Y EDAD EN EL CAMBIO VELOCIDAD-PRECISIÓN

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ABSTRACT

Introduction: Extraversion/introversion and age differences might influence speed-accuracy tradeoff. Objective: The speed-accuracy tradeoff was investigated in extroverted and introverted female children, young adults and older adults. Method: Participants carried out an alternative version of Fitts' task, which involved making alternate clicks with the mouse held in the dominant hand, moving as fast as possible, on two rectangular targets on a computer screen in order to make twelve attempts at six random levels of difficulty (twelve combinations of target widths and distances between targets). Each of the three groups was composed of 16 introverted and 16 extroverted subjects, based upon Brazilian versions of Eysenck's questionnaire. Results: Elderly introverts fell short of the target more often and committed more overall errors than the elderly extroverts. Additionally, compared to their younger adult counterparts, the elderly subjects fell short of the target more often and committed more overall errors, besides taking longer to complete the task with higher levels of difficulty. Conclusion: The findings were interpreted in light of theories designed to explain the main processes underlying extroversion/introversion and age-related differences. ***Level of Evidence II; Lesser quality prospective study.***

Keywords: Introversion/psychology; Personality; Individuality; Motor skills.

RESUMO

Introdução: Diferenças de extroversão/introversão e idade podem influenciar na troca velocidade-precisão. Objetivo: A troca velocidade-precisão foi investigada em garotas, jovens adultas e idosas extrovertidas e introvertidas. Método: As participantes realizaram uma versão alternativa da tarefa de Fitts, a qual consistia em clicar alternadamente com a mão dominante no mouse, o mais rápido possível, em dois alvos retangulares na tela do computador, a fim de fazer doze tentativas em seis níveis aleatórios de dificuldade (doze combinações de larguras e distâncias entre os alvos). Cada um dos três grupos era composto por 16 introvertidas e 16 extrovertidas, com base nas versões brasileiras do questionário de Eysenck. Resultados: As idosas introvertidas acertaram menos o alvo com mais frequência e cometeram mais erros gerais em comparação às idosas extrovertidas. Ainda, as idosas acertaram menos o alvo com mais frequência e cometeram mais erros gerais, além de demorarem mais tempo para concluírem as tarefas com níveis maiores de dificuldade quando comparadas com as jovens adultas. Conclusão: Os achados foram interpretados com base nas teorias criadas para explicarem os principais processos sobre as diferenças relacionadas à extroversão/introversão e à idade. ***Nível de Evidência II; Estudo prospectivo de menor qualidade.***

Descritores: *Introversão/psicologia; Personalidade; Individualidade; Habilidade motora.*

RESUMEN

Introducción: Las diferencias de extroversión/introversión y edad pueden influir en el cambio velocidad-precisión. Objetivo: El cambio velocidad-precisión fue investigado en mujeres jóvenes adultas y de la tercera edad introvertidas y extrovertidas. Método: Las participantes realizaron una versión alternativa de la tarea de Fitts, que consistía en hacer clic alternadamente con el ratón, usando la mano dominante, lo más rápidamente posible, en dos objetos rectangulares en la pantalla de la computadora, a fin de realizar doce tentativas con seis niveles aleatorios de dificultad (doce combinaciones de anchos y distancias entre los objetos). Cada uno de los tres grupos fue compuesto por 16 introvertidas y 16 extrovertidas, con base en las versiones brasileñas del cuestionario de Eysenck. Resultados: Las mujeres de tercera edad introvertidas acertaron menos el objeto con más frecuencia y cometieron más errores generales en comparación a las mujeres de tercera edad extrovertidas. Además, las mujeres de tercera edad acertaron menos el objeto con más frecuencia y cometieron más errores generales, además de demorar más tiempo para concluir las tareas con niveles mayores de dificultad cuando comparadas con las mujeres jóvenes adultas. Conclusión: Los hallazgos fueron interpretados con base en las teorías creadas para explicar los principales procesos sobre las diferencias relacionadas a la extroversión/la introversión y a la edad. ***Nivel de Evidencia II; Estudio prospectivo de menor calidad.***

Descriptores: *Introversión/psicología; Personalidad; Individualidad; Destreza motora.*

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INTRODUCTION

The speed-accuracy tradeoff (SATO) principle was formalized by Paul Fitts as the inverse relationship between the target's width/amplitude and the speed with which it can be performed.[1,2] Fitts task involves tapping, with a handheld stylus, alternately between two rectangular target plates, as rapidly as possible for twenty seconds. Indexes of difficulty (ID) have been defined as a function of target's amplitude (movement distance) and width (size) so that the less wide and close are the targets, the longer is the movement time (MT). In other words, the task becomes more difficult in terms of speed and accuracy as the targets are far and/or narrow. It is possible to plot the relationship between IDs and MTs into a regression line, whose slope depends on the performance in a series of trials with different IDs. SATO, also known as Fitts law (FL), is a landmark that has long been studied in the field of motor behavior, being one of the most robust and highly adopted models of human movement.[3] FL has reached a remarkable generality as it was successfully supported by a number of studies in underwater condition, with different ages and diverse muscle effectors, with small movements, when movements were only imagined, and with pointing, reaching, and grasping movements.[4]

Although FL has been shown to hold well for all ages,[3,4] age-related differences has been reported. Despite grown-ups of different age did not differ whether ID was manipulated through amplitude or width,[5] children and older people do seem to show higher slopes of the regression lines (ID x MT) when compared to young adults.[6,7] Children and elderly therefore appear to be more sensitive to changes in ID and this age-related sensitivity is one clue to believe that individual differences might influence SATO. In this sense, we see that personality traits are personal characteristics that may distinctively affect motor behavior. Distinct personalities might lead individuals to react differently to the same stimulus or situation as indicated by personality-related differences that have been reported in sensory sensitivity. Introverts are likely to be more reactive and sensitive to auditory/pain thresholds and noise than extraverts.[8,9] Extraverts tend to show more reactive behavior facilitation system than that of introverts, as weak stimuli seem to be insufficient to induce behavioral facilitation for introverts.[10] In addition, because introverts have the disposition to be more accurate and slower than extraverts when following a moving cursor with a stylus,[11] they tend to self-select strategies that match position (accuracy strategy). It has been also shown that MT differentiate extraverts from introverts, since the former exhibit shorter movement durations than the latter when performing motor tasks.[12-16]

Extraversion-introversion (E-I) is a broaden, robust, and stable personality trait that is central to prominent models and inventories of personality. Extraverts have the predisposition to be sociable, impulsive, talkative, and fond of changes, whereas introverts tend to reflect before acting, have an ordered life, carefully control their feelings and to be calm, retracted, introspective, and reserved.[8,9] E-I differences have been discussed in terms of arousal, the basal cortical activation level, which is higher in introverts and lower in extraverts. Accordingly introverts are likely to avoid excessive stimulation sources, whereas extraverts tend to "hunt" stimuli.[8] Neurobehavioral studies on the relationship between cortical activation and E-I have given support to arousal-related differences between introverts and extraverts.[13-15,17-19]

The studies mentioned earlier have given evidence to the effect that efforts have been made to extend FL to different contexts and that a great deal of research has been accumulating on motor performance differences between introverts and extraverts. It is not clear, however, whether personality could influence SATO. It was our goal therefore to investigate, through a cross-sectional experiment, the performance of extraverts and introverts females (children, young adults and elderly) on a SATO task. Our study differs from previous research on E-I and FL in several important ways. First, we designed and performed the study in order to merge E-I- and age-related differences into the FL paradigm. We believe that this intertwined approach will broaden our understanding of how individual differences manifest in motor control. Second, we view this study from the perspective that preferences and needs can play an important role in motor behavior.[20-22] Given that in FL investigations on age-related differences, the effects of IDs as a function of personality traits have not yet been investigated, we raise the issue that E-I individual differences may influence the performance on the Fitts task. Considering the different characteristics of introverts and extraverts, the aim of this paper is to assess whether, in performing the Fitts task, errors and ID x MT changes can be observed for both extremes of the E-I trait.

The abovementioned findings from FL studies in the motor domain and the fact that introverts exhibit a reduced sense of space to perform movements[23] lead us to expect that introverts will tap more accurately but slower, whereas extraverts will tap faster but inaccurately when performing the Fitts task. Introverts would therefore adopt an *accuracy* strategy, responding to higher IDs with higher MTs and reduced errors. Rather, extraverts would use a *speed* strategy showing lower MTs but more errors. Also, it is arguable to expect higher slopes of older people in the regression lines that represent the relationship between MT and ID.[24-26] In addition to the old people's desire of being perceived as younger than they really are and hence doing the best to be accurate (not fast), aging-related noise contributes to diffuse neuron loss so that the activation of relevant neurons to perform motor tasks is weakened in old people, and, as a result, they tend to take more time to integrate perception and action.[27-30]

MATERIALS AND METHODS

Given that lower levels of extraversion have been observed in women as compared to men,[31] only female participants took part in the experiment. Using the Brazilian versions of Eysenck's Questionnaires,[32,33] we first screened the personalities of 272 people and then selected 96 to be actual participants. Ranging from 8 to 85 years of age, they were self-declared right-handed, nonsmokers, and had normal hearing and normal or corrected-to-normal vision. All participants and parents/tutors signed an informed consent form and were naive about the task and the experimental hypotheses. This study has been approved by the university ethics committee, under the protocol 13549708 (CAAE 0009.0.186.000-11).

Thirty-two children, ranging from 8 to 11 years (M ± SD = 9.3 ± 0.86 years), were assigned to one of two groups: introverts (n=16) and extraverts (n=16). The Brazilian version of Children's Eysenck Inventory[32] was used to screen the children's personality. This version is composed of 30 items and screens Psychoticism (0-11), Extraversion-Introversion (0-10), Neuroticism (0-7), and Lie Scale (0-6). We considered participants with E-I scores less than 4 to be introverts and participants with E-I scores greater than 7 to be extraverts. We arbitrarily excluded participants who scored between 4 and 7 in order to include only extreme scores in E-I. Only the children who scored within the average variation on Psychoticism (6.0 ± 2.0), Neuroticism (4.0 ± 2.0) and had low levels on the Lie Scale (less than 3) were included.

Likewise, thirty-two undergraduate students (young adults), ranging from 17 to 40 years (M ± SD = 22.7 ± 2.7 years), were assigned to the same groups (introverts and extraverts, n=16, each). Their personalities were screened by the Brazilian version[33] of Eysenck's Personality Questionnaire [EPQ-R].[34] This version consists of 88 items and screens Psychoticism (0-25), Extraversion-Introversion (0-18), Neuroticism (0-23), and Lie Scale (0-22). We considered participants with E-I scores less than 12 to be introverts and participants with extraversion scores greater than 16 to be extraverts. We arbitrarily excluded participants who scored between 12 and 16 for the same reason aforementioned (children). In the sample we only included those who scored within the average variation for Brazilian women[31] on Psychoticism (3.5 ± 2.0) and Neuroticism (15.8 ± 2.0), and low levels on the Lie Scale (less than 6). This same procedure was used to assign thirty two older adults (who ranged from 70 to 85 years, 67.3 ± 4.1 years) to groups of introverts (n=16) and extraverts (n=16).

A computer-adapted version of the Fitts task was used.[35] Amplitude (A) and width (W) were identical of those used by Fitts[2] so that the targets were 6 inches long, 2, 1, 0.5 and 0.25 inches wide and the targets were distant 2, 4 and 8 in. Thus, there were twelve combinations and six indexes of difficulty. The 16 in. distance from Fitts' study was not used due to computer screen restriction boundaries. We used Dell Computers hardware, an Optiplex 790 desktop, an E1911C 19-inch flat panel monitor and an MS111 wired-USB optical mouse (1.75 x 3.75 inches).

Mouse options were set as default, with the white arrow pointer pending to the left at medium speed. We run the task on the 32-bit Windows 7 Professional Operational System.

The participant was welcomed in a quiet room by the experimenters and sat comfortably in an adjustable chair so that the center of the computer screen was at a convenient height and angle. The mouse was placed on the table at approximately 8 inches in front of the computer. The participant held the mouse with the right hand midway between the targets. Each of the twelve trials lasted 15 seconds and was followed by a 55 seconds resting period. Each participant performed one familiarization trial (ID=3) before starting the test.

The following was read to each participant prior to the familiarization trial: "Strike these two target strips alternately. Score as many clicks as you can. If you hit either of the side strips an error will be recorded. You will be given a 2 second warning before a trial. Place your hand here and start tapping as soon as you hear the buzzer. Emphasize accuracy rather than speed. At the end of each trial I shall tell you if you have made any errors." These instructions were identical to those used by Fitts,[2] with the exception of the words "strip" instead of "plate" and "click" instead of "hit"/"tap".

Each participant performed 12 trials through a randomized sequence of amplitude and width target combinations. Mouse, monitor, and chair settings were standardized for all participants.

Statistical analysis

We computed a click outside the boundaries of the target as an error, which was expressed as the percentage of errors that were too long (overshoots), too short (undershoots), and the sum of these two (overall error).

Time was represented by the MT and was expressed in seconds as the average time between clicks, during 15 seconds, for each ID, according to the following formula: MT = 15 / number of clicks. For each participant and group, we run a linear regression analysis, whose equation $MT = b_0 + (b_1 * ID)$ expressed the relationship between the ID [log 2 (2A/W)] and the MT. The b_0 in the regression formula stands for the y-intercept and the b_1 for the slope of the regression line. The coefficient of determination (r^2) was also calculated and indicated the portion of the total variance in MT that can be explained by the variance in the ID.

We run a MANOVA 3-way [E-I (introverts and extraverts) x age (children, young and older) x ID (1-6)] for the errors (overshoots, undershoots, and overall) and a MANOVA 2-way [E-I (introverts and extraverts) x age (children, young and older)] for the regression coefficients (b_1, b_0 e r^2) regarding the relationship between MT and ID. Sidak's post hoc tests were used for multiple comparisons of age-related group differences. For follow-up E-I comparisons within age for each ID, we carried out independent samples T tests. When appropriate, F-ratios were reported with the adequate degrees of freedom adjustment. η^2 were also reported to indicate effect sizes for significant results. Alpha was set at 0.05 for all analyses.

RESULTS

Table 1 presents the means and standard errors of overshoots, undershoots, and overall error values, in percentages, of introverts and extraverts by age and ID. Instead of standard deviation (whose values were high due to an increased frequency of zeros in the low IDs), we show standard error to give an idea about the minimum and maximum boundaries of the 95% confidence intervals. The MANOVA detected a significant effect for the interaction "E-I x age x ID" [F(10,1116)=1.88; p=0.044; η^2=0.17]. Sidak procedure showed that the introverted old women made more (a) undershoots than the introverted children and young women when performing the IDs 3, 4, 5 and 6, (b) overall errors than the introverted children when performing the IDs 5 and 6, and (c) overall errors than the introverted young women when performing the IDs 3, 4, 5 and 6.

Because Sidak post hoc procedure could not identify E-I related differences within age groups, we used T tests to verify whether there were differences between introverts and extraverts within the old group. The analyses indicated that the introverts made more undershoots and overall errors than the extraverts on ID3 [t(52.70)=2.18, p=0.034; t(58.84)=2.11, p=0.039], ID5 [t(38.87)=2.55, p=0.015; t(40.63)=3.13, p=0.003] and ID6 [t(21.29)=2.45, p=0.023; t(23.17)=2.09; p=0.048]. Also, introverts made more overshoots than the extraverts on ID5 [t(41.64)=2.35, p=0.024].

The group's values from the regression equations (MT x ID) are shown in Table 2 and Figure 1 depicts the regression lines. The MANOVA

Table 1. Means (M) and standard errors (SE) of the percentage of error.

		Introverts		Extraverts	
	Age	M	SE	M	SE
Undershoots					
ID1					
	Children	0.00	0.00	0.00	0.00
	Young	0.16	0.15	0.00	0.00
	Old	0.00	0.00	0.85	0.61
ID2					
	Children	0.85	0.37	0.75	0.32
	Young	0.46	0.19	0.57	0.19
	Old	4.69	2.57	0.20	0.19
ID3					
	Children	1.84	0.47	0.49	0.38
	Young	0.56	0.23	1.61	0.53
	Old	6.92*^	2.45	1.41°	0.60
ID4					
	Children	2.94	0.85	1.88	0.62
	Young	1.16	0.40	1.37	0.37
	Old	7.16*^	1.98	4.57°	1.72
ID5					
	Children	2.10	1.10	2.19	1.15
	Young	1.95	0.71	1.91	0.65
	Old	15.99*^	4.18	4.66°	1.50
ID6					
	Children	1.76	0.96	1.30	0.96
	Young	1.42	0.78	2.05	0.80
	Old	17.78*^	4.74	4.93°	2.22
Overshoots					
ID1					
	Children	0.71	0.51	0.24	0.23
	Young	0.21	0.21	0.00	0.00
	Old	0.37	0.37	0.30	0.30
ID2					
	Children	0.46	0.22	1.40	0.64
	Young	0.96	0.79	0.94	0.36
	Old	0.21	0.20	1.04	0.62
ID3					
	Children	2.84	0.77	2.00	0.60
	Young	0.80	0.31	1.21	0.44
	Old	1.90	0.81	1.22	0.59
ID4					
	Children	3.18	0.75	3.21	0.92
	Young	2.62	0.85	2.79	0.67
	Old	3.00	1.08	1.44	0.57
ID5					
	Children	2.44	0.80	2.26	0.89
	Young	2.57	0.82	3.58	1.03
	Old	5.84	1.79	1.28°	0.75
ID6					
	Children	3.01	1.41	3.38	2.29
	Young	2.02	0.98	2.70	1.15
	Old	4.55	1.95	4.36	1.73
Overall errors					
ID1					
	Children	0.71	0.51	0.24	0.23
	Young	0.37	0.25	0.00	0.00
	Old	0.37	0.37	1.15	0.66
ID2					
	Children	2.30	0.59	2.15	0.75
	Young	1.19	0.42	1.42	0.45
	Old	4.90	2.57	1.24	0.64
ID3					
	Children	4.67	0.95	2.50	0.68
	Young	1.37	0.47	2.82	0.77
	Old	8.82*	2.76	2.63°	0.99
ID4					
	Children	6.12	1.29	5.10	1.30
	Young	3.78	0.99	3.85	0.81
	Old	10.16*	2.30	6.01	2.02
ID5					
	Children	4.54	1.53	4.45	1.66
	Young	4.89	1.29	5.48	1.16
	Old	21.84*^	4.72	5.93°	1.88
ID6					
	Children	4.77	1.81	4.68	2.44
	Young	3.44	1.37	4.74	1.54
	Old	22.33*^	5.47	9.28°	2.98

*old x young; ^old x children: p<0.05 differences among introverts. °introverts x extraverts: p<0.05 differences within the old group.

Table 2. Means (M) and standard deviations (SD) of regression variables.

		Introverts		Extraverts	
	Age	M	SD	M	SD
Slope					
	Children	0.21	0.05	0.25	0.12
	Young#*	0.15	0.03	0.14	0.03
	Old	0.29	0.26	0.28	0.15
y-Intercept					
	Children	0.45	0.36	0.38	0.15
	Young	0.19	0.08	0.22	0.08
	Old^*	0.78	0.78	0.62	0.31
r^2					
	Children	0.80	0.16	0.79	0.12
	Young	0.88	0.07	0.88	0.14
	Old^*	0.51	0.32	0.54	0.22

^children x old; #children x young; *young x old: p<0.05 differences among ages.

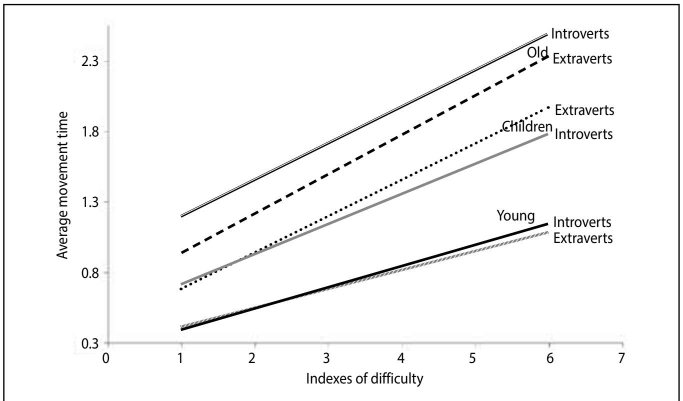

Figure 1. Regression lines of the groups as a function of movement time and index of difficulty.

did not reveal significant effects neither for the interaction "E-I x age" nor for the main factor "E-I". However, the main factor "age" produced significant effects on y-intercept, slope and r^2 [$F(6,172)=17.66$; $p=0.0001$; $\eta^2=0.38$]. Sidak procedure indicated that the older women showed larger y-intercepts than the children and the young women, the slope values of the young women were smaller than those of the children and the older women, and the older women showed lower values of r^2 than the children and the young women.

DISCUSSION

We examined SATO from a personality trait standpoint with the purpose of providing insights into the role of individual differences in motor behavior. Errors and the relationship between MT and IDs of girls, young and older women who scored high and low in E-I were analyzed to test whether introverts would perform Fitts task accurately but slower. Data from girls and young women showed no E-I-related differences and data from older women refuted the stated prediction. Compared to their extraverts counterparts and to children and young introverts, the introverted older women made more undershoots so that they appear to have performed narrow movements (i.e., too-short pathways between targets), a reduced sense of space that has already been reported in introverts while gesturing.[23] The introverted older women might have used diminished movement amplitude to optimize the execution of the side to side clicking. This strategy is called "undershoot bias" (UB), which has been associated with reduced energy expenditure and time to correct an error when moving in a noisy environment.[36-39] UB is more prominent when the targets to be tapped are distant[40,41] and when tapping with the right hand.[42] Our data seem to give support for these findings, given that the introverted older participants self-declared to be right-handed and made more undershoots when performing at the highest IDs.

Considering that we did not measure cortical activation, we can only speculate that the execution of the task by the introverted elderly engendered an arousal shift from high basal levels to an even higher cortical activation, probably much beyond the optimal point.[8] Introverts were expected to show higher MTs than extraverts when performing the Fitts task, but our data did not show any E-I-related difference in the regression coefficients (MT x ID). Data from girls and young adults did not allow us to draw any conclusions, even speculative, on cortical activation.

MT should have differentiated extraverts from introverts.[12,15] Excitation states are stronger in introverts when analyzing stimuli and in extraverts when organizing responses,[43] so that it is tempting to assume that extraverts would respond faster than introverts. Despite the fact that we did not compare group's MTs directly, our analysis of the regression coefficients failed to show any E-I-related differences. According to the principles of the optimized submovement model,[44] determining the optimal MT for a given task will involve a compromise between higher velocity movements that get the limb to the target area quickly and the variability associated with more forceful movements. To perform our clicking sideways task, we believe that the participants executed the action from the start state, observed the resulting state and executed the action from that state again, trying to click on the targets in a sequence of movements. When performing such a task there is an increased likelihood for UB, which may be related to the involvement in determining the spatial distribution of primary movement endpoints associated with the forces required to accelerate and decelerate the limb.[37,45] Thus, it is arguable that the performer is required to seek for optimal solutions either by maximizing the use of feedback or diminishing MT.[46,47] It seems that our introverted older women adopted a "play-it-safe" approach to the task, and, as a result, the mean of the distribution fell short of the center of the target, i.e., greater number of undershoots. This indicates a failure to use online feedback correctly as it was probably difficult to discover over multiple trials how fast they were able to move without missing the target.[48,49]

Movements are at least partially adjusted with online feedback through closed-loop control.[3] Thus, it seems plausible to believe from the undershoots data that the interaction between E-I and aging processes might have led the introverted older women to engage in complex processes. Given that sensorial feedback is the key source of information to perform the Fitts task (i.e., tactile information of the mouse and visual information of hand movements and cursor), the large number of errors made by the introverted older women could be explained by a longer time to process the feedback in sensorial, perceptive, decision, and effector levels. Clicking with the mouse alternately from side to side might have posed an overload problem to deal with feedback information on clicking to the right side along with clicking to the left side in a row.

As previous aging research has pointed out,[25,26] higher IDs elicited higher MTs in older women when compared to young women. The "software" problem that can explain impaired or slower performance in the elderly is the fact that they do not want to be considered as so. To be as accurate as possible, older people normally perform tasks slowly than young counterparts. In addition, another possible account of our results appears to be a "hardware" problem related to biological degradation, as either neuronal loss or inability to recruit relevant neurons reduces the strength of signal stimulation to perform motor tasks. Thus, weak signals need to be recognized from a great deal of noise, slowing the process of perception and action, even greater when ID increases.[27,29,30] The findings of the present study seem to give support to the notion that older people are more sensitive to changes in ID since the slope values of the young women's regression lines were smaller than those of the elderly.[3] Additionally, y-intercepts and r^2 values in the older women groups corroborate reported age-related differences in SATO.[50,51] For instance, kinematics strategies to reach the target while performing the Fitts task demonstrate that young adults show a richer repertoire of strategies than elderly people, who employ a strategy of submovements to reach the goal.[5] The combination of these age-related strategies with personality traits calls for further investigation.

Whereas in the original Fitts experiment participants made an average percentage of overall errors of 1.25%, our adults made 3%, and even higher percentages were achieved by our children (4%) and older women (6%). One hypothesis that seems to account for these results is the virtual environment and the mouse manipulation. The amount of experience and/or exposure to computers is an intervenient variable that may have affected the results. It is not likely that children and young adults in most developing/developed societies have had no exposure to mice while using computers, whereas the lack of exposure could be a real problem for older people.[52] It is possible to argue that only older extraverted women have had some experience with computers, while older introverted women just try to avoid it. We highlight therefore the need to investigate levels of exposure to computers, especially in older people.

In the present study, we controlled for the eye's line of gaze matching to the monitor's center, but all participants handled the same mouse. We should thus address this limitation concerning the size of the mouse, which has been reported as an intervenient variable, especially for children.[53] Also, as online control is thought to be more prominent with practice and might reduce both inherent variability resulting from noise and performer variability over the final phases of the movement,[36] another suggestion for future research is to investigate the impact of practice sessions in introverts and extraverts. Over several trials, people can enhance the performance on Fitts task by reducing the spatial variability associated with primary movement endpoints and by keeping the center of the distribution just short enough of the target center.

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