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Age-related switching costs in adulthood: "All or None Hypothesis" corollaries

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Age-related switching costs in adulthood: "*All or None Hypothesis*" corollaries

Abstract

This study proposed, firstly, to test three of the five corollaries that comes from the "*All or None Hypothesis*" (Diamond, 2009), in an adult population (young adults, older adults and oldest-old adults). Secondly, we aimed to analyse the functioning controlled mode changes, during three developmental stages in the adult population. The sample included 147 participants (61 adults, 63 older adults, and 23 oldest-old adults). Participants performed the Fingers Task (a modified version of the Arrows experimental task; see Davidson et al., 2006). We found a clear decrease in behavioural measures (i.e. TR) associated with ageing in the discriminative and controlled cognitive processing mode. The obtained results verified the three age group corollaries and identified the described controlled mode changes at each age group (young, older and oldest-old adults), during adulthood.

Keywords: Cognitive Flexibility, Switching Task, Adulthood, Ageing, All or None Hypothesis corollaries

Key Points

- Question: What is the key question this paper addresses?

To verify three of the *All or None Hypothesis*' corollaries in three age groups of adult population (young adults, older adults, and oldest-old adults) as well as to explore the age effects on the cognitive functioning controlled mode.

- Findings: What are the primary findings?

The results verify the three corollaries for each age group and identify the described functioning controlled mode changes, at different developmental stages during adulthood (young adults, older adults and oldest-old adults), showing slower RTs in G3 (i.e. oldest-old adults group).

- Importance: What are the key scientific and practical implications of the findings?

Our findings may be useful in cognitive flexibility training for elderly populations. These specific programmes would be crucial to improve their quality of life by fostering adaptive skills in changing situations, and consequently, reducing the risks of neurodegenerative pathologies in everyday life.

- Next Steps: What directions should be explored in future research?

It would be desirable to use a probability sampling method, and to replicate the experimental tasks used on the present work but testing additionally some stimuli variations on onset asynchrony in order to validate our findings on different task settings. Additionally, we propose that those experimental tasks variations could be also studied with clinical samples.

Introduction

In recent years, the increase in life expectancy (i.e. thanks to advances in medicine and public health) has produced an ageing effect on the population worldwide. In this sense, numerous investigations have been carried out around the world on the relationship between aging and cognitive impairment, and a great inter-individual variability has been observed (e.g., Baltes et al., 2006; Gajewski et al., 2020) not only in the Western world but also elsewhere. For example, in the study by Yuan et al., (2021), they found that cognitive decline was highly correlated with the occurrence of 1-year adverse health outcomes (i.e. death, frailty and decreased Health-related quality of life -HRQoL-) in elderly hospitalized patients in China. The study by Shen et al. (2021) found an effect of aging on cognitive level, and that cognitive function declined more rapidly after age 80 years among older adults in urban China. Older age, singleness, and lower occupational cognitive requirements increased the likelihood of cognitive risk. And the incidence of cognitive impairment in Singapore was reported as 22 per 1000 person-years (Feng et al., 2017). Cognitive impairment may be related to an increased risk of developing disability in Japanese older adults (Shimada, et al., 2016).

At brain structure level, the observed variability has been mainly explained by important factors related to neurodegeneration (e.g. grey matter atrophy, see Draganski et al., 2013) that might be contributing with performance age-related differences. Li et al. (2020), investigated longitudinal changes in whole brain Functional Connectivity Strength -FCS- and cognitive performance scores in very old individuals without cognitive impairment, and found changes in FCS with aging with precuneus as the axis. Liang et al. (2020) found that older individuals with Subjective Cognitive Decline -SCD- recruited from the community are associated with structural and functional changes of the hippocampus, and these changes may serve as potential biomarkers of SCD. In Alzheimer’s disease (AD) it was found (Ferreira et al., 2017) that 10 to 20 years prior to dementia diagnosis, it can be observed evident manifestations of neurodegeneration while individuals are still functioning as cognitively average. However, functional neuroimaging studies explained this effect based on the occurrence of adaptive brain plasticity paralleling the observed neurological deterioration.

In recent years, many researchers studied age-related differences in executive functioning, as it may contribute to cognitive decline. For instance, the “switching behavioural task” is a well-known experimental procedure for measuring executive function developmental changes, by assessing two switching cost: (i) the attentional ability to maintain and select stimulus among several task sets (i.e., general switching costs) and (ii) the switching ability between tasks (i.e., specific switching costs). The “switching behavioural task” assesses those switching costs (i.e., general and specific) on the so-called “mixed blocks” that introduce change demands between two or more tasks rules (for a review on these task characteristics see Kray & Ferdinand, 2014). In this sense, there is relevant empirical evidence that shows that both types of changing cost are involved on different switching task components (for more details on the changing costs types and their theoretical foundations see Grange and Houghton, 2014). We think that it is necessary to deepen our understanding of the existing differences between optimal ageing (i.e., where cognitive functioning is preserved) and cognitive deterioration caused by aging. In this regard, new findings can be relevant for the design of early interventions, even in middle adulthood (Cabeza et al., 2018). Additionally, we consider it relevant to further analyse cognitive changes throughout the lifespan, especially those related to cognitive abilities that showed age-related differences.

The elderly population is known to perform worse than younger adults on all reasoning tests and tasks (e.g., Fisk & Sharp, 2002; Tommerdahl et al., 2016). In this regard, some authors attributed this age-related decline to changes in cognitive control processing functions (Gombart et al., 2016). In this sense, one of the current main debates on this research area is related to the description of the “elderly processing mode” (i.e. based on specific cognitive processing strategies) that might be explaining how the elderly population compensates for some typical cognitive deficits. From this perspective, it has been argued that well-learned daily routines (so-called "cognitive pragmatic"; Baltes, 1997) can be proposed as the core reason that could explain how older adults perform well on everyday tasks. Therefore, the experience with a specific problem context fosters higher than expected levels of problem solving abilities (Allaire, 2012; Strough & Keener, 2014).

Diamond (2009) also proposed the *All or None Hypothesis* acknowledging that the human mind can act mainly by a default global functioning, and by activating a more selective, discriminate and controlled processing way only when necessary. Accordingly, a set of corollaries were proposed to test the *All or None Hypothesis* on different processing domains (i.e., perception, behaviour and cognition). To this regard, in the present work, we aim to analyse three of these five corollaries, on the adult population.

The *first corollary* that we choose to analyse states that when something must be changed in relation to a certain activity, it is always easier to change the complete piece of information (i.e., by activating a global processing mode) instead of performing a partial change. This effect has been extensively documented both on adults and children (e.g., Kleinsorge, 1999; Meiran, 2000; Rogers & Monsell, 1995; Schuch & Koch, 2004) and can be assessed using mainly behavioural switching tasks that can analyse three main experimental conditions: (i) absence of change, (ii) total change and (iii) partial change. Accordingly, Davidson et al. (2006) evaluated a sample aged from 4 to 13 and young adults. They found that fewer errors were made in the total change condition in comparison with the partial change condition, verifying the statement of this corollary on both age samples.

The *second corollary* postulates that it is effortless to process salient stimuli aspects throughout a global mode than processing a few of its qualities using a controlled mode. In other words, the privation of orienting attention to dominant attributes implies a more discriminative processing mode. In this sense, different arguments have been proposed for explaining these findings. For instance, Allport and collaborators (1994; Allport & Wylie, 1999) argued that these outcomes can be explained by the existence of a change cost, being a type of proactive interference effect that might be responsible for the observed data. From this approach, the so-called "changing costs" can emerge from a state of prolonged activation of mind-sets that can only slowly decline over time and consequently obstruct partially relevant aspects of task execution. Conversely, Rogers and Monsell (1995) argued that it might be a dissimilarity between endogenous and exogenous control mode task components. Additionally, the Failure-To-

Engage (FTE model, De Jong et al., 1999) provided an alternative explanation of the phenomena based on the analysis of the successful use of cognitive early preparation. The "Simon effect" (i.e. the tendency to orient the attention to the location where the stimulus has been presented; Hommel et al., 2004; Lu & Proctor, 1995; Simon, 1990), also provided scientific findings that supported this corollary. The Simon task (e.g., Kornblum & Lee, 1995; Simon, 1990) demands an ipsilateral response to the stimulus (stimulus/response site congruent) and participants normally present more accurate and faster responses than when a contralateral response to the stimulus is required (stimulus/response site incongruent). Thus, a worst performance in the incongruence condition is explained based on the fact that the participant must inhibit visual salient stimulus characteristics in order to focus their attention on the relevant but less salient attribute (i.e. the direction in which the stimulus is pointing), thus supporting the second corollary.

Lastly, the *third corollary* suggests that it is easier to inhibit a principal response permanently by a global mode processing than to do so only from time to time. Regarding this, inhibiting a dominant response, as indicated in Corollary 2, requires effort, but when that inhibition must be continually and consistently sustained using a global mode processing, it doesn't demand that high processing cost, as it is stayed in corollary three. In other words, having to constantly alternate between inhibiting a dominant response on some occasions and giving the dominant response other times, demands an extra processing cost (Davidson et al., 2006; Kirkham et al., 2003; Waszak et al., 2003).

Evidence in healthy older adults showed that there are significant differences in total cost of change conditions and that these results could be associated with age (e.g. Gajewski et al., 2010; Kray & Lindenberger, 2000). They explained this body of results in relation with the well-known difficulty of the adult population in maintaining multiple information sets on their working memory. However, other studies have shown that in older adults, changing costs related to age are small or non-existent when the behavioural measurement is taken from the overall Response Time, considered as a general cognitive processing measure (e.g., Craik & Salthouse, 2011; Kray & Lindenberger, 2000; Mayr, 2001). In this sense, a recent study made on different age groups, found that the cost of global change is significantly higher on elderly populations compared to younger adults, even when co-variables are considered, showing consistent results of advanced age general cognitive slowdown (e.g. Kray & Lindenberger, 2000; Mayr, 2001). In addition, Kray and Lindenberger (2000) and Mayr (2001) found greater age differences in overall costs than in partial change costs. In this sense, it is worth mentioning some scientific studies populations (e.g., Eich et al. 2016; Meiran et al.; 2001) that analysed cognitive change´s cost on elderly populations, measured by conflict trials (i.e. congruence/incongruent), and found: a significant interaction between task switching, congruence, and age (i.e., implying a greater congruence effect on the "condition of change" in comparison with the condition of "no change" in older adults in comparison to younger adults). In those studies, older adults showed greater difficulty than young people in selecting from potentially relevant stimuli when the stimuli appeared in a changing context. That is, in most of these studies, age-related difficulties were found under the condition of a greater uncertainty of the task, where they didn´t have clear environmental cues helping them assess the correct answer (e.g., Bruine de Bruin et al., 2012). Conversely, when the behavioural task is more predictable and external cues are shown on the trials, older people found it easier to organise and anticipate the response type they must give, thus reducing age-group differences on global change costs measures (Kray et al., 2002).

Participants typically underestimate the incongruent condition difficulty when the stimuli are on the opposite side, and they also sometimes make mistakes because they answer based on the “rhythm of predictability” of the task. Likewise, the advantage of the easier condition (congruent) is underestimated when participants must alternate between that response and the incongruent one; this happens because people’s performance tends to slow down in contexts of change. To this respect, Introzzi et al. (2019) found relevant evidence on an adult sample for the three mentioned corollaries, showing that adults might have a global response processing mode that is scarcely identified in previous research, and that is activated by default in situations where appear behaviours or thoughts that are not very analytical and differentiated. However, in contexts that demand a greater discrimination, this global mode is substituted by a controlled mode that requires a superior cognitive effort and more a discriminated processing mode.

To date, there are no studies to our concern that have attempted to systematically analyse these corollaries across age groups in middle and later adulthood. Corollary analysis in diverse populations (i.e. children, adults, typically and atypically developing older adults) provide specific evidence regarding cognitive control or controlled processing mode. This information is particularly relevant because of the important contribution of controlled processing in activities of daily living (e.g., Hazlett et al., 2015) and in different complex cognitive functions (e.g. Introzzi, 2021; Hasher et al., 2007; Johns et al., 2012). There are few studies that have explored the analysis of this type of processing through specific tasks that allow different corollaries to be assessed independently. Although there are studies that have explored this issues in children populations, adolescents and middle-aged adults (Davidson et al., 2006; Introzzi, et al., 2020, 2018), there is still no research reported in older adults populations. To this goal, on the present study, we aim firstly, to verify three of the *All or None Hypothesis*' corollaries in adults, older adults, and oldest-old adults and, secondly, to explore and discuss the age effects on cognitive functioning controlled mode, specifically on age sub-groups that were not analysed in previous research and have theoretical relevance to be explored.

Method

Participants

An intentional and non-probability sample was assessed. The sample was distributed in three groups: Age Group 1(G1): Adults from 40 to 59 years of age (*n*= 63) (*M*=49.43; *SD*=6.23); Age Group 2 (G2): Older adults from 60 to 74 years of age (*n*= 61) (*M*=67.32; *SD*=3.87); and Age Group 3 (G3): oldest-old adults aged 75 years or more (*n*= 23) (*M*=80.81; *SD*=6.05).

Participants were selected from non-governmental organizations, and adult course programs done by the National University of Mar del Plata (UNMdP, Buenos Aires, Argentina. For the sample selection, we considered the following inclusion criteria for adults: (a) not in psychiatric treatment; (b) no diagnosis of psychiatric and/or neurological impairment, focal or degenerative diseases; (c) normal or corrected vision; (d) formal education of at least seven years in total; and (e) for adults over 60 years old, scores greater than 25 to 27 points in the *Mini Mental State Examination* (MMSE) according to their age and educational level (Argentine version of Butman et al., 2001). The MMSE is a brief test widely used worldwide for rapid screening of cognitive impairments, which are more frequent in people over 60 years of age, so its use is usually recommended in studies with this population. The adaptation and the Argentine norms used in this study indicate a cut-off score between 25 and 27 points for the population over 60 years of age. According to Butman et al. 2001, it is to be expected that the score in this test decreases with age and increases with more years of formal education.

Instruments

For the analysis of the three corollaries: We used a classic *switching task* (i.e., version of the arrow task proposed in Davidson et al., 2006). We selected this task because it demands the ability to quickly change between different execution rules and responses. This instrument was included in a platform called Cognitive Self-Regulation Tasks (Introzzi & Canet Juric, 2019) under the name of “Finger Task” (i.e. on this task, images of a hand pointing with the index finger are used as stimuli instead of arrows).

The task consisted of three experimental blocks that were presented in the following sequence: Congruent Block (CB), Incongruent Block (IB) and Mixed Block (MB), (for an example of the trials see Fig. 1). Prior to the presentation of each experimental block, a practice block of eight trials appeared. Each practice block was the same as the corresponding experimental block, the only difference was that they had fewer trials and that the performance therein was not accounted for in performance analysis. If it was the case that the participant failed to respond correctly in 80% of the practice block trials, the experimental block didn´t begin, and the practice block was administered again until this threshold was reached.

The CB block: The CB is the first block. In this block, a hand appears with a finger pointing straight down on the left or right side of the screen, and the participant had to press the ipsilateral key of the site where the stimulus is presented (i.e., "Z" or "M", on the keyboard). Therefore, when the stimulus appeared on the left side, the participant had to press the "Z" key and when it appears on the right side, the “M” key. In the experimental block, 10 stimuli were presented on the left side and 10 on the right side, distributed randomly.

The IB block: When the CB was completed, the IC appeared with its corresponding practice block; both being composed only by incongruent trials. In this case, the stimulus consisted of a hand with its index finger pointing in a diagonal direction (at a 45° angle) to the opposite side in which it is presented. Thus, if the hand appeared on the right side of the screen, it pointed to the contralateral response site and the participant had to press the letter "Z". Conversely, if it appeared on the left side, the finger pointed out to the contralateral response site and the participant had to press the "M" key. In summary, the diagonal-pointing hand always points to the opposite side, indicating that the key that is contralateral to the side where the stimulus is presented is the one that must be pressed. In this case, the practice block consisted of eight trials and the experimental block consisted of 20 (in 10 trials the stimulus is presented on the right side of the screen and in the other 10 it is presented on the left side). In both cases the stimuli are distributed randomly.

The MB block: Following the IB, the MB was presented with its corresponding practice block of eight trials. In both cases, congruent stimuli (hand pointing straight down) and incongruent stimuli (hand pointing to the opposite side) appeared, distributed randomly. The practice block consisted of four congruent and four incongruent trials (half of the stimuli of each type were presented on the left side of the screen and the other half were presented on the right side). The experimental block consisted of 40 trials: 20 congruent and 20 incongruent. The stimuli were distributed pseudo randomly and respecting the following conditions: 20 stimuli on the right side (10 congruent and 10 incongruent) and 20 stimuli on the left side (10 congruent and 10 incongruent).

The MB was based on a classic switching behavioural task paradigm. The participant must switch quickly and effectively between two incompatible rules (pressing on the same side or on the opposite side). For this reason, execution in the mixed block requires a continuous configuration and reconfiguration of mental operations (Davidson et al., 2006; Monsell, 2003; Roger & Monsell, 1995; Wylie & Allport, 2000).

In all blocks, the following sequence was repeated: first a fixation point (a cross) appeared on the centre of the screen and remained fixed throughout the block. Next the stimuli appeared sequentially on the left or right side of the cross at an equidistant distance and with a stimulus interval of 500 ms. Each stimulus remained on the screen for 750 ms., during this time period the participant had to give his or her response (See *Modifications to the design and configuration of the fingers task for older and older adults).* Performance in the experimental blocks yielded a set of basic performance measures: (a) the average of correct answers, (b) the average on response time (RT) by trial type (i.e. congruent and incongruent) and (c) the number of given anticipatory responses (i.e. responses emitted in 200 ms. or less).

Modifications on "fingers experimental task "for older adults.

Following the conclusions assessed on a pilot study (*n*=15), a series of modifications were made to the original task (Davidson et al., 2006): (1) Instead of arrows as stimuli, fingers are used for the purpose of increasing the participant's familiarity with the stimuli and to facilitate the association between each stimulus and the response (i.e., the key that the participant is asked to press based on the type of stimulus presented). Secondly, (2) modifications were made to the task instructions. In general, changes were made based on the age group being tested. For adults and older adult's language was more formal, the graphic interface was simpler and characters were omitted. Lastly, (3) changes were made regarding the time a stimulus remained on the screen and the interval between stimuli. For older adults, the interval is 1000 ms. (instead of 500 ms.), and each stimulus remained on the screen for 2000 ms. (instead of 750 ms.). This last modification was done only for the age groups 2 and 3 (i.e., older adults and oldest-old adults).

Insert Figure 1

Operative description of corollaries, hypotheses, and expected results

Corollary 1: *When something must be changed in relation to a certain activity, it is always easier to change everything or change nothing than to change just one aspect.*

As mentioned in the Introduction, this corollary was analysed under three conditions: (a) absence of change; (b) partial change; and (c) total change. In operative terms, conditions (a) and (c) correspond to the global mode, so they should be simpler than condition (b), which requires a more discriminate response. In summary, according to the All or Nothing Hypothesis, while conditions (a) and (c) represent the indiscriminate default acting mode, option (b) represents a more specific operation, which consequently requires greater control and cognitive effort.

The mixed block allows us to obtain a set of indexes that reflect the performance in each of these conditions, which makes it ideal for testing this corollary. That is, the absence of change - condition (a)- is obtained from the average RT and the accuracy (ACC, number of correct answers) in trials with no change of rule or response site; that is, the condition in which a trial repeats the same rule (congruent or incongruent) and the same response site ("Z" or "M'' key) as the trial immediately preceding it. Both indexes reflect performance in trials preceded by trials that are exactly the same in terms of both the rule and the response site. On the other hand, condition (c) represents the inverse situation: total change. This condition includes the average RT and ACC in trials where the rule and response site change with respect to the preceding trial. Finally, the partial change condition (b) is analysed based on the average RT and ACC in trials that requires a rule change but not a response site change with respect to the preceding trial (Different Rule Same Site-DRSS; Figure 2) as well as in trials that require the same rule but a different response site (Same Rule Different Site-SRDS; Figure 2).

In summary, according to the All or None Hypothesis, partial change indexes should reflect a higher RT and less accuracy (ACC) than total change and absence of change indexes (corollary 1a). Additionally, this hypothesis assumes that an age-related performance decline in the controlled mode will occur; hence a significant increase in RT and decrease in ACC is expected based on participants' developmental stage (adults, older adults and older adults) (corollary 1b).

Insert Figure 2

Corollary 2: *It is easier to process the more salient aspects or attributes of an object or stimulus than just process some of its features.*

This corollary argued that it is easier to respond to the salient or dominant features of a stimuli than to those that are less salient, since in the latter case it is necessary to ignore the salient attributes, which implies a more discriminate or specific processing way.

The used task is conceptually based, in part, on the Simon experimental effect described in the introduction. That is, the tendency to respond at the same site where the stimulus was presented, makes the ipsilateral condition (stimulus-response congruence) more convenient than the contralateral condition (stimulus-response incongruence). In other words, the task relevant attribute is the direction in which the finger is pointing, since it indicates the response site. However, the relevant attribute (direction of the stimulus) is less salient and prominent than the irrelevant attribute (location of the stimulus), and the connection with the response site is weaker and must be established over the course of a few trials. Conversely, the irrelevant attribute is more salient and is biologically connected to the response site because it is based on a physiological response of the processing system.

Thus, according to what is proposed in corollary 2, we expected the participants to have shorter RTs and to be more accurate: (a) in trials where the stimuli are located at the same side of the correct response key (i.e., congruent trials) and (b) where the global and automatic mode is sufficient, than in those trials where the stimuli are located at the opposite side of the correct response key (i.e., incongruent trials). In addition, there should be expected an age-related performance decline (corollary 2b).

Corollary 3: *It is easier to inhibit a dominant response all the time than it is to do so only sometimes.*

This corollary states that although inhibition implies a cognitive control effort, it is easier to inhibit the response all the time than only on certain occasions. In other words, it establishes that it is easier to always act the same way than to sometimes act one way and at other times in another way.

In "finger task", inhibition is involved in both the IB and the MB, as both include incongruent trials that compel the participant to inhibit dominant response (i.e., by ipsilateral response). The fundamental difference between the IB and the MB blocks is the proportion of incongruent trials present in each of them. Thus, while in the IB 100% of the trials are incongruent, in the MB only 50% of the trials are incongruent. This experimental task characteristic made it possible to have two conditions: condition (a) IB, in which the participant must inhibit the salient response in all the tests, and condition (b) MB, in which the participant must only inhibit the salient response in 50% of the trials.

According to the All or None Hypothesis, although inhibition is considered a process that requires control and effort, condition (a) constitutes a less complex and discriminate activity than condition (b), which requires inhibition processing only in certain trials. Therefore, in condition (b) the tendency to respond in the same way must always be controlled, as the activity also includes congruent trials requiring another type of response (i.e. non-inhibitory trials). This statement is normally assessed by a significantly better performance in the IB compared to the MB (i.e., the so called “block effect” in this experimental task), and a better performance in trials that are preceded by a trial of the same type than in those that are preceded by a trial of a different type, on mixed blocks (i.e., the so called “change effect”, when the participant must respond to an incongruous trial preceded by a congruent one or vice versa, that is, when changes the type of response) (corollary 3a). Similarly, in relation with corollary 3b, it is worth noting the so- called effect of age-related impairment (i.e., can be assessed by a worse performance, on the processing controlled mode, on mixed block trials, and involve a rule change in older age groups).

Table 1 below summarises the corollaries and the indices that allow the evaluation of each of them.

Insert Table 1

Procedures

Participation in the study was voluntary and based on informed consent. Thus, the informed consent form explained the objectives of the study and described the task to be administered. It also made it clear that the data was confidential and that the results would only be used for research purposes in accordance with the Argentine National Law (i.e., Nº 25326 on the protection of personal data and in accordance with the "Guidelines for

Ethical Behaviour in Social Sciences and Humanities" of the Ethics Committee-CONICET); Resolution No. 2857, 2006 of the Board of Directors of the National Council of Scientific and Technical Research, following the Ethical Principles and Psychologists Conduct Code, and according with was established by the American Psychological Association (A.P.A., 2017). The participants performed the tasks individually on laptops, in a quiet place, without any external interruptions. The duration of the task was approximately 10 minutes.

Data analysis

RTs for each trial were registered for each participant. Trials with anticipatory responses (under RT 200ms) were excluded. Once the data were collected, the *Z* scores of the main variables were obtained, and those participants that showed scores beyond 2.5 deviations were eliminated (i.e., atypical multivariate cases, *n*= 9). Before the statistical tests were applied, the *trade-off* effect was analysed (i.e., which refers in this case to the "response style" adopted by the participants). Basically, this "response style" effect indicates if during the performance of the task the participant chose to take more time to respond (i.e., sacrificing response speed in order to maintain a more accurate performance or vice versa; Kreutzer et al., 2011). The absence of correlations between RT and ACC on any measure, on any corollary, allowed us to consider RT and ACC as independent measures of performance.

In order to analyse the differences between the controlled and global processing's modes, and to evaluate the age-related performance effect on the controlled mode, mixed ANOVAs were applied and included the measures described in the section "Operative description of corollaries". Based on the ANOVA`s results, *post hoc* and pairs comparisons were made to identify the differences. Prior to the comparison of each corollary, the "normality assumption" was tested for most measures (Kolmogorov-Smirnov and Shapiro-Wilk p> 0.05). Additionally, we analysed the equivalence of variance/covariance matrices for between-group factors, using M de Box test and the assumption of sphericity of variance/covariance matrix, using Mauchly's test (Mauchly, 1940). In general terms, this assumption was checked, and epsilon corrector Greenhouse-Geisser (Greenhouse & Geisser, 1959) was used for adjusting some measures. In cases in which the homoscedasticity assumption was not tested, the comparison method Games Howell was used; and in the rest of the comparisons the Bonferroni method was applied.

Results

In first place, an analysis of the number of correct trials in the different blocks of the Flexibility Finger Task and in the different conditions of change, discriminated by age group was made. The number of correct answers was lower in the mixed block (Cognitive Flexibility index) and in the congruent block (processing speed index) for the older group (Group 3: 75 years or older). In the incongruent block, on the other hand, the number of correct answers in Group 2 (60 to 74 years) was lower, but without significant differences (see Table 2).

Regarding the different conditions of change, in all the groups the global processing mode of total change was the one that presented the least number of correct trials, followed by the partial change type of response, the partial change site of response and finally the absence of change (where the site and response type do not change). This condition was the one that presented the highest number of hits, being significantly lower for Group 3 (14/23) compared to Groups 1 (56/63) and 2 (53/61).

Insert Table 2

In second place, a data analysis control of variables gender and socio-occupational level was made. Because no significant effects of these covariates were found, they were not reported in the results.

Corollary 1:

Table 3 shows mean scores and standard deviations for the dependent variables by change condition and Age Group.

Insert Table 3

A mixed ANOVA (corollary 1a) showed a main effect of Change in RT F (3, 306.56) =6.872, $p < .001$, ηp^2 =.32, and Age Group F (2, 135) = 16.271, $p < .001$, ηp^2 = .19. A significant Change x Age Group interaction, with F (3, 306.56) = 4.266, $p < .001$, ηp^2 = .05, was also revealed. In order to analyse interactions, differences between conditions of change for each group and differences between age groups for each condition were calculated. Regarding the ACC, repeated measures ANOVA (corollary 1a) the analysis showed a main effect of Change in ACC F (3, 53.407) = 4.654, $p < .05$, ηp^2 =.03. Comparisons of the main effects of conditions on RT and ACC were analysed. Post hoc comparisons were made between the groups in the different measures of change using the Bonferroni method. Because the

ACC measures in DRSS did not show equivalent variances between the groups, the Games-Howell method was applied for this comparison. Post-hoc Comparisons revealed the following significant (p<.001) effects: a)Absence of change vs Total change in ACC measures; b)Partial change DRSS vs Total change comparisons, not only in G1 but also in G2 RT measures; and c)Partial change SRDS vs Total change in G1 and G3 measures.

With regard to the age-related performance effect on the controlled mode, the performed ANOVA showed a Group effect on different RT-based change measures [SRDS (F (2) = 14.410, *p*<.001); DRSS (F (2) = 8.116, *p*<.001) and Total change in SRSS, *F* (2) = 19.218, p<.001 and DRDS *F* (2) = 22,264, p<.001. Regarding ACC, a group effect was found only for Total change [SRSS (F (2) = 3.186, *p* =.04)]. In relation with the obtained differences between groups, for the different measures of change, we found the following significant effects, in RT measures (i.e. p<.001) on the performed comparison between age groups: a)No change vs SRSS, in G1 compared with G2 and in G1 compared with G3; b)Partial change vs SRDS, in G1 compared with G2 and in G1 compared with G3; b)Partial change vs DRSS, in G1 compared with G2. We also found p=.01 marginal significant effect, in RT measures, in Partial change vs DRSS, when comparing G1 with G3. Lastly, a marginal significant effect (p=.02) was found in Total change vs DRDS, in G2 vs G3 comparison.

Figure 3 showed the change effect for RT and ACC

Insert Figure 3

Corollary 2:

We compared the performance between CB and IB, on different age groups, through mixed ANOVAs. With respect to TR, a Condition effect was found, *F* (1,135) = 121,963, $p<.001$, $\eta p^2=.475$; an Age Group effect, *F* (2,135) =19.153, $p=.001$, $\eta p^2=.221$; and an interaction effect between the Age Group and the Condition, *F*(2,135)=7.131, $p=.001$, $\eta p^2=.096$. In ACC, a Condition effect was found, *F* (1,135) = 23,183, $p<.001$, $\eta p^2=.147$; absence of Age Group effect, *F* (2,135) =. 559, $p=.573$, $\eta p^2=.008$; and absence of interaction effect between Age Group and Condition, *F* (2,135) =1.031, $p=.360$, $\eta p^2=.015$. In relation to the Condition effect, increased RTs and decreased ACC, on the IB (see descriptive statistics, Table 4) and indicated that targeting the less salient aspects of the stimulus required a more controlled and discriminative processing (corollary 2a) and, according to the peer comparisons in the framework of the interaction between Age Group and Condition, this effect was observed on the three groups, except in the G3 for the ACC index (Table 5). Regarding the effect of age group found in RT, the post hoc comparisons showed that not all groups differed significantly, with respect to the performance in both blocks. Specifically, it was observed that the G1 differed from the other two groups, while between the G2 and G3 no significant differences were found (corollary 2b; Table 5). Figure 4 shows average RT in CB and IB for all groups.

Insert Table 4

Insert Table 5

Insert Figure 4

Corollary 3

We analysed the existence of the two expected effects, block effect and change effect, in three age groups and, in their RT and ACC measures, through mixed ANOVAs. Regarding the performance of the groups in IB and MB, in terms of RT, we observed a Block effect, $F($1,135)=58,633, p<. 001, ηp^2 =.303; Age group effect, F (1,135) = 20,916, p<. 001, ηp^2 =.237; and absence of interaction effect between Age Group and Block, F (2,135) = 1.053, p=. 352, ηp^2 =015. Considering the ACC, the test results indicated no Block effect, F $($1,135) = 3.436, p=. 066, ηp^2 =.025; no effect of Age group, F (2,135) = 1,223, p=.297, ηp^2 =.018; and absence of interaction effect between Age Group and Block, F (2,135) = . 599, p=. 551, ηp^2 =.009. However, with regard to the Block effect found in RT, a better performance (lower RT) was observed in the IB in comparison with MB (see descriptive statistics, Table 4). The differences in performance between the two blocks showed to be significant and were observed in three age groups. This was also reflected in the peer comparisons made in the for the Age Group and Block effect interaction (corollary 3a; Table 6). However, in relation to the Age Group effect (considering RT), peer comparisons indicated that G1 differed from the remaining two groups, while G2 and G3 do not differed significantly (corollary 3b; Table 6).

Considering the performance (RT and ACC) of the participants in the conditions with and without change within the MB, with respect to the RT was found Condition effect, F (1,135) =195.264, p<. 001, ηp^2 =.591; Age group effect, F (2,135) =18,098, p<001, ηp^2 =.211; and interaction effect between Age Group and Condition, F(2,135) =5,954, p=. 003, ηp^2 =.081. In relation to ACC, the results indicate Condition effect, F (1,135) =175,217, p<. 001, ηp^2 =.565; no effect of Age group, F (2,135) =. 224, p=. 799, ηp^2 =.003; and absence of interaction between the Age Group and the

Condition, *F* (2,135) =. 271, *p*=. 763, ηp^2 =.004. Regarding the Condition effect, descriptive statistics showed better performance (lower RT and greater ACC) in the condition without change compared to the condition with change (see descriptive statistics, Table 4). The difference in performance in both conditions was statistically significant (corollary 3a) and was observed in all age groups (Table 6). Regarding the effect of Age Group (found for RT), the post hoc evidence again indicated that G1 differed significantly from the rest of the groups, while on the overall performance G2 and G3 did not differ under these conditions (corollary 3b, Table 6). Figure 5 shows average RT in IB, MB and in the conditions with and without change, for all groups.

Insert Figure 5

Discussion

Nowadays, it is well established that the human mind functioning changes at different developmental stages. To this end, many neuroscience and psychological researchers considered it important to analyse the default processing mode (i.e., automatically, uncontrolled, fast and global processing way, see Diamond, 2009; Frankish, 2010; Kahneman, 2011; Saab, 2011). This default processing mode is often opposed to a finer and more precise way that would be activated in situations where the overall mode is not effective. On the other hand, when this more precise and discriminated cognitive processing way is ongoing, it seems to require more effort, be slower and to demand a higher amount of cognitive control resources. However, the “more distinguished processing way” is the one that is in charge of processing complex and novel situations for which we do not have learned and firmly established strategies (e.g., Introzzi, 2016). As mentioned in the introduction, Diamond (2009) conceptualizes this as the *All or None Hypothesis* posing a set of complementary corollaries that contrast this general idea about the functioning of the cognitive system.

Previous studies empirically contrast this set of corollaries in some developmental stages such as childhood, adolescence and adulthood (e.g., Introzzi et al., 2019; Introzzi, Richard’s et al., 2020; Richard´s et al., 2018, 2019, 2020). However, to our knowledge, these corollaries have not been analysed in elderly population. Therefore, the main objective of this study was to empirically analyse these corollaries related to ageing.

The research carried out by Introzzi et al. (2019) was done on the same research perspective and extends the contrast of these 3 corollaries postulated on Diamond`s work (Diamond, 2009) to other developmental stages, such as early and middle adulthood. Then, as follows, we will discuss the main results of the present study by highlighting new findings of the present work, seen as a continuity of the results obtained from the developmental stages studied (e.g., Introzzi et al., 2019) to late adulthood, older adults and older adults).

Following the *All or None hypothesis*, and regarding corollary 1, it was expected that: (1) the partial change condition would demand a greater effort and cognitive control to participant´s cognitive processing, than the condition of total change, and (2) that the condition of total change would require a greater effort and discriminative ability to participant´s cognitive processing, on to the absence of change condition, in all groups. Conversely, the RTs results showed a different picture. That is, we found that all groups were slower in “total change condition” and faster in “absence of change condition”. In general terms, we argue that this tendency showed that in “absence of change condition” the cognitive processing was faster, although less selective and discriminated and the opposite was observed on “total change condition”.

It is worth noting that our results showed we can define differential performance profiles by age groups in adults, depending on their performance on different change conditions. Thus, the younger adults and older adults presented similar RTs in the conditions of total change and in one of the partial change conditions - (i.e. SRDS, change of response site)-. Thus, in these groups, the task demand amount seemed the same for both change conditions (i.e. total and partial change-SRDS-). However, in these conditions, the RTs decreased in comparison with the other condition of partial change -DRSS (response type change: congruent or incongruent) where they responded significantly faster, maybe because this condition is simpler and more global. Finally, we can observe a significant decrease in RTs when comparing DRDS with the absence of change conditions (i.e. where typically all groups present faster and automatic responses). However, in the older adults evaluated, the described profile changes slightly as the condition of total change is different from the other conditions by being linked to slower responses, and suggesting that this turned out to be the condition of change that generated greater difficulty and higher amounts of cognitive control for older adults. To this respect, we observed that “total change” condition performance can be completely differentiated from the two partial change conditions, in the older adults age group.

Regarding ACC measures, they only showed significant differences in adult groups when we compared “total change condition” with “the absence of change condition”, finding better ACC`s indexes in “absence of change condition". In summary, our results are coherent with what Davidson et al. (2006) pointed out for adult populations, remarking that, unlike in children, the response ACC does not usually discriminate between different conditions, as is the case with TRs.

Considering the set of results obtained on adults, we can conclude that the corollary 1 has been partially confirmed, given that although there are clear differences in performance between "total change" condition and "absence of change" condition, the total change seems to work mainly when a more complex condition is set and when it requires a greater control and cognitive effort than the amount of control needed on "partial change" condition. In this sense, in the context of the corollary 1, changing everything clearly requires a controlled mode of operation, while the absence of change implies an automatic and global cognitive system functioning mode. However, partial change requires a more automatic processing mode than the one needed for total change condition. These results differ from those obtained in the study conducted by Introzzi et al. (2019) where younger adults acquired, as the corollary suggests, their worst performance in the condition of partial change. A possible explanation of these results can be found in the participants' development stage. Introzzi et al. (2019) worked with a unique group of adults aged 18 to 57, while here participants aged 40 and over (with a larger sample, and three age-groups). Cognitive functioning changes throughout life spam. These changes can be observed in terms of improvements or difficulties in performance on cognitive tasks. But also, changes in the structure and the mode in which cognitive functioning operates can be observed (e.g., Glisky et al., 2020). Thus, it is possible that corollary 1 is not observed similarly at different stages of adulthood due to changes in how cognitive functioning operates. Although the Introzzi et al.

(2019)' study included participants of the age group 1 of this work, many of the subjects were younger adults (including emerging adults). The performance of these participants may be linked to the results, which differ from those observed here.

In all the studied conditions we verified the so- called “performance age effect”. As it was found by Introzzi et al. (2019), we obtained that TRs measures discriminate more and show greater variability than those based on ACC. In summary, in the present work we can observe that as the age of the participants increases they are slower in “change conditions” (total and partial). However, in the condition of absence of change -which requires an automatic response and less cognitive control- there is also an additional decrease in the speed of response, that is coherent with the well-known “slowing down effect” of RTs during adulthood (e.g., Kail & Bisanz, 1992; Kail & Salthouse, 1994; Salthouse, 1993, 2017).

With respect to corollary 2, lower TRs and ACC were expected in the trials of the task where the most salient and least salient attributes required the same response location (i.e., in congruent trials), since in this case there is no conflict between the required responses. Thus, in congruent trials, the location (i.e. based on irrelevant but salient aspects of the stimulus) and the orientation of the stimulus (i.e. relevant but less salient aspects of the stimulus) was concurrent and both were associated with the same ipsilateral response. To this respect, the correct answer was activated through a global, fast and automatic mode. However, when the stimulus was incongruent, to give the contralateral correct answer was necessary to focus attention on the less salient characteristic of the stimulus. It is worth noting that this type of attention processing required a controlled, discriminative and less automatic response. Therefore, in these cases, we found that the

TRs and errors increased in the Incongruent Block in comparison with the Congruent Block, in all age groups. Therefore, these findings allowed us not only to confirm the corollary 2, but also to point out that they are coherent with previous studies that assessed complex cognitive functions (e.g. such as selective attention which involves control cognitive effort processing; Baumeister et al., 2007; Diamond, 2013; Hasher et al., 2007; Treisman & Gelade, 1980; Treisman & Sato, 1990).

With regard to this second corollary, we also wondered whether the controlled and discriminated mode was needed to respond in incongruent trials and if there were changes throughout adulthood and old age. To this respect, the obtained results didn't show ACC differences between groups, but they showed significant RTs differences on performance measures. In this sense, although the two older groups performed similarly, younger adults differed from the two older adult's groups by presenting lower RTs. These findings suggested that the most controlled and discriminated cognitive system mode (i.e. that was set for processing the incongruent trials) might show a slow down after the age of 60, moment from which it seems to remain stable, at least until the age of 74. It is worth remarking that these findings are consistent with previous evidence obtained on elderly population (e.g. Cinzia et al., 2003; Jacques & Marcovitch, 2010) showing that the controlled processing mode started to show a noticeable decrease among the ages between 50 and 60. However, ACC did not show differentiated profiles according to the age group and remained relatively stable as age increases in these later stages of life, which can imply that adults and older people can perform with slower reaction times (RTs) but with a preserved level of ACC response, that is to say they were slower in responding at the cost of being accurate.

Lastly, in relation to corollary 3, two empirical hypotheses were analysed in the sense that we expected that the participants showed: (a) the analysis of the so-called “change effect” in the sense of a better performance in trials that were preceded by trials of the same type (i.e. congruent or incongruent) than in those that were preceded by a different type; and (b) the analysis of the so-called "block effect". That is, we expected an age decreased performance in MB trials (i.e., involving a rule change and in the controlled processing mode, and in which only inhibition was required in some of the trials) compared to the IB trials (i.e. which required inhibition in all trials). To this respect, a better performance (faster RTs) was observed in the IB in relation to MB; and the difference in performance between the two blocks shown to be significant and was observed in the three age groups. Therefore, based on this evidence, we can infer that the demand for change implied a more controlled processing mode that manifested in a worse RT performance. This performance pattern is coherent with the results reported by Davidson et al. (2006) and those obtained in other more recent studies that focus on other stages of development (Introzzi et al., 2019; Richard´s et al., 2019).

With respect to the analysis of the age-related changes hypothesis in the performance in both blocks (i.e. based on the post-hoc RTs comparisons by age group), we observed significant differences in all age groups, delimiting different performance profiles. Specifically, it was observed that G1 (i.e., 40 to 59 years of age) differs from the other two groups, while between the G2 and G3 (i.e., that were all participants over 60 years of age) showed no significant differences. For it, it could be argued that the RTs performance pattern of younger adults differs significantly from that of older people, observing that as the age of people increases their processing mode requires greater efforts and cognitive control, and becomes less discriminative and more global.

In summary, the data obtained allowed us to draw two general conclusions regarding the cognitive functioning mode in adults: (a) performance worsens due to the increase of the combined speed and accuracy demands; (b) a more discriminative functioning mode is linked to a greater cognitive control, and is related to a clear cognitive decrease associated with age, this is revealed in a RT slowdown in G2 (older adults) and G3 (oldest-old adults), compared to G1 (i.e., adults), but showing a similar accuracy cost in these three age groups.

In relation to our first general conclusion (a), it is worth noting that as people face tasks that require more discriminative processing, their performance worsens, which is especially reflected in RTs. For it, the main question at this point is to explain why performance decreases. In this sense, as different authors considered (Eich et al., 2016; Kray & Lindenberger, 2000; Mayr, 2001; Meiran et al. 2001), and as showed to be consistent with the data obtained on the present work, the performance decrease can be due to cognitive control because requires higher cognitive effort and inhibitory processing (i.e. on the present study it corresponds to the ability to quickly change between responses and thoughts, the so-called “switching flexibility”). In other words, we propose that the more discriminative processing mode is needed, the more additional cognitive control processes is required (i.e. mainly with respect to simpler tasks that require a more global mode) and we think that is precisely why there is shown a decrease in performance in those tasks that demands greater response discrimination.

Related to our second general conclusion on adult population (b), our results showed that the more discriminated and controlled cognitive processing mode, the clearer decrease associated with age is observed. Thus, generally speaking, from the age around 60, adults begin to experience a decline in the discriminated mode. Additionally, as it was explained in the Introduction, younger adults typically show a discriminative processing mode, mainly evidenced by a significant decrease in RTs (i.e., better RTs performance). In this sense, the described pattern was observed on adult´s age groups assessed on the present work and shown to be similar to what was found in children populations (e.g. Introzzi et al., 2020a, 2020b), which shown to be especially evident in the RTs performance of the different fingers task activities. However, ACC measures did not show differences between the three adult age groups studied, and remained relatively stable in the later stage of life, showing that the oldest-old participants presented slower RTs but a level of preserved ACC, that is to say they were slower in responding at the cost of being accurate.

On the other hand, we also observed TRs performance significant differences between the G1 with G2 and G3 (i.e., between: G1 - 40 to 59-, G2 -60 to 74-, and G3 -75 to 85-). In this sense, we found statistically significant differences between the young adults' performance profiles with respect to older and long-lived adults, being these findings also coherent with recent findings (e.g., Introzzi, et al., 2020b). On the other hand, we found no significant differences between the last two groups, G2 and G3, meaning that the CF performance pattern is higher in the G1 than in the G2 and G3, being these data consistent with recent scientific findings (e.g. Gajewski et al., 2020).

The present work also has some limitations that should be mentioned: firstly, the sample size and secondly, the sampling method (i.e. because we used a non-probabilistic sampling method). Regarding the first mention limitation, we think that it could be important in future work to analyse larger and context-diverse samples. Secondly, we think that the selection method can be improved in future research by using probabilistic sampling. There are previous studies that show a slowdown in response times in oldest-old adults (Chen et al, 2017; Hardwick et al., 2022) and our results go in the same direction. However, future research should consider a greater number of adults, either considering different age groups or focusing only on this age group. Finally, we used longer stimuli exposure for G2 and G3 than for G1, and these trial design variations should receive more validation data in future research in order to further support our findings.

Regarding future research lines, we recommend the replication of our study with clinical samples (i.e. especially focused on neurodegenerative pathologies). In this sense, we think that obtaining data from these clinic subpopulations could be useful and informative, especially for obtaining interesting research data about: (a) the change effects costs, and (b) older adults and daily life deterioration of their cognitive skills. To this respect, we think that further studies in this specific area could design training programs (e.g., neuro-feedback) for enhancing cognitive flexibility. We think that these clinical applications could have an impact on elderly quality of life by fostering their adaptation to changes, and consequently reducing neurodegenerative pathologies risks.

It is known that cognitive functioning changes throughout the lifespan and aging involves a daily performance cognitive functioning decline . However, understanding what these changes are and how cognitive functioning operates at this stage is essential to design appropriate approaches to promote cognitive functioning in daily life, to prevent cognitive impairment and to recover it under conditions in which this is possible (Guye et al., 2021). Knowing, for example, that a "total change" experimental task setting generates is more cognitive consuming than "partial change" and both can serve both for cognitive evaluation and cognitive strengthening (i.e. especially when inhibition and cognitive flexibility are required). The present work intends to contribute in this sense.

Conflicts of Interest

No potential conflict of interest was reported by the authors.

Data availability statements

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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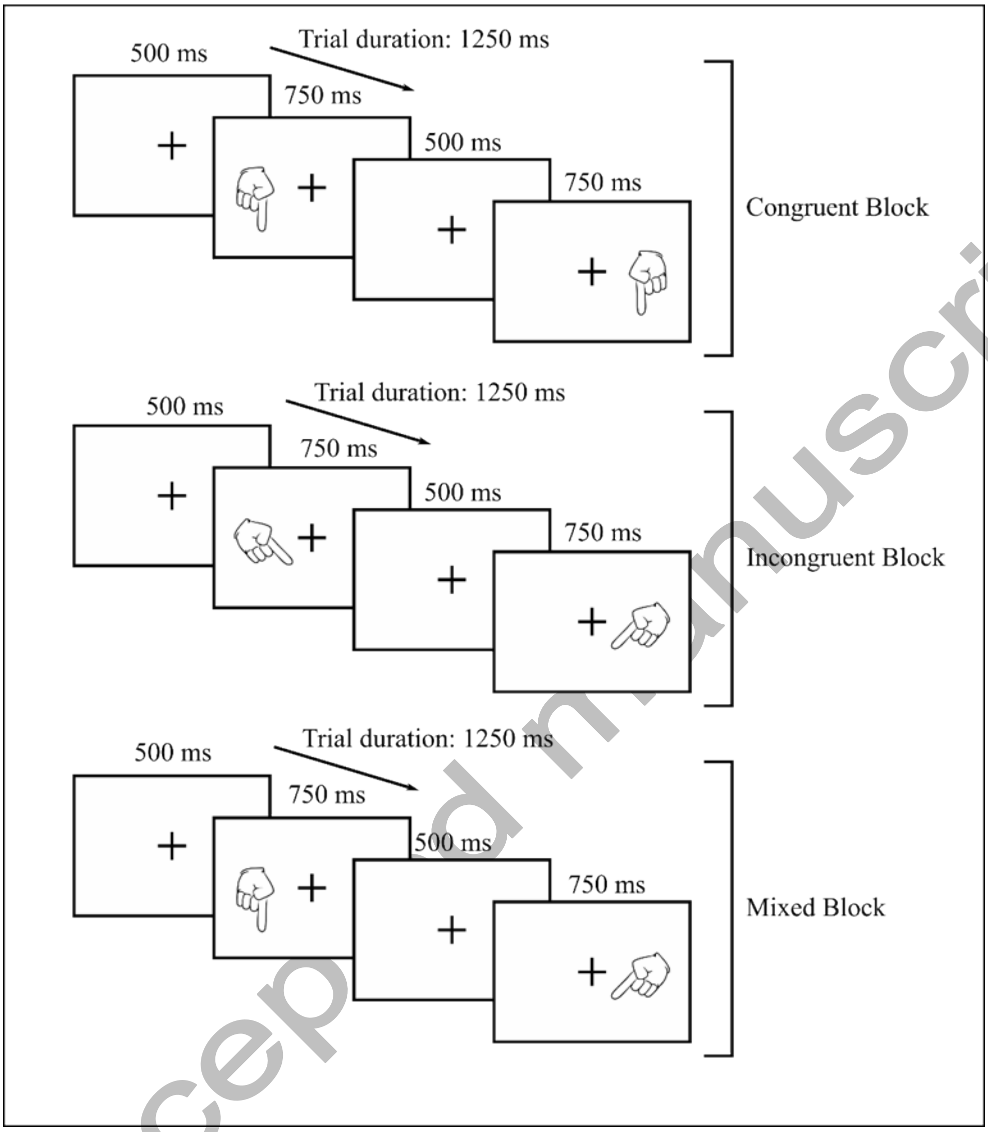

Figure 1. Fingers Task, Trial sequence.

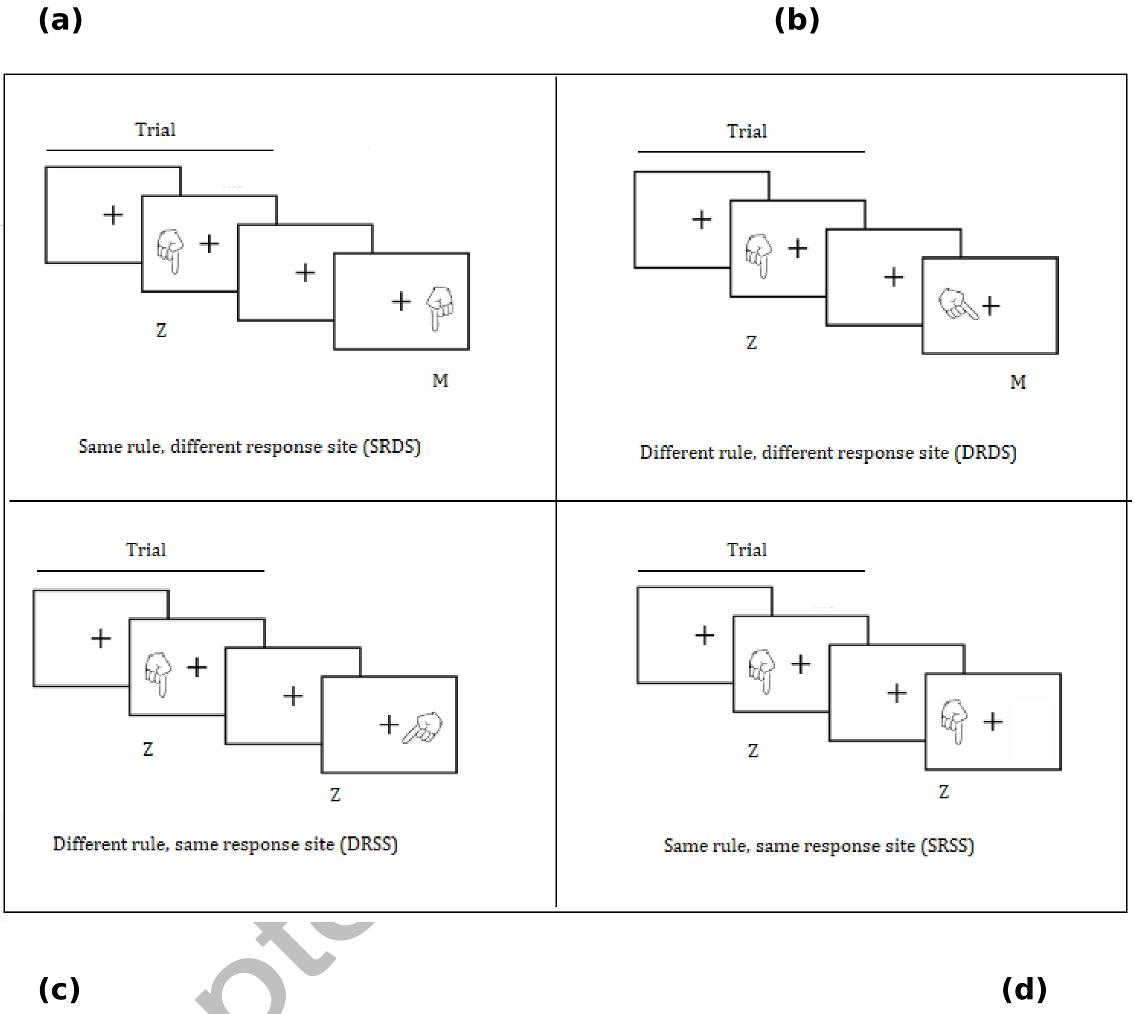

Figure 2. Examples of the four conditions in the Mixed Block, with two consecutive trials in each case. (a) and (c): *Partial change*, cognitive processing mode discriminated; (b) and (d): *Total change and Absence of change*, global cognitive processing mode.

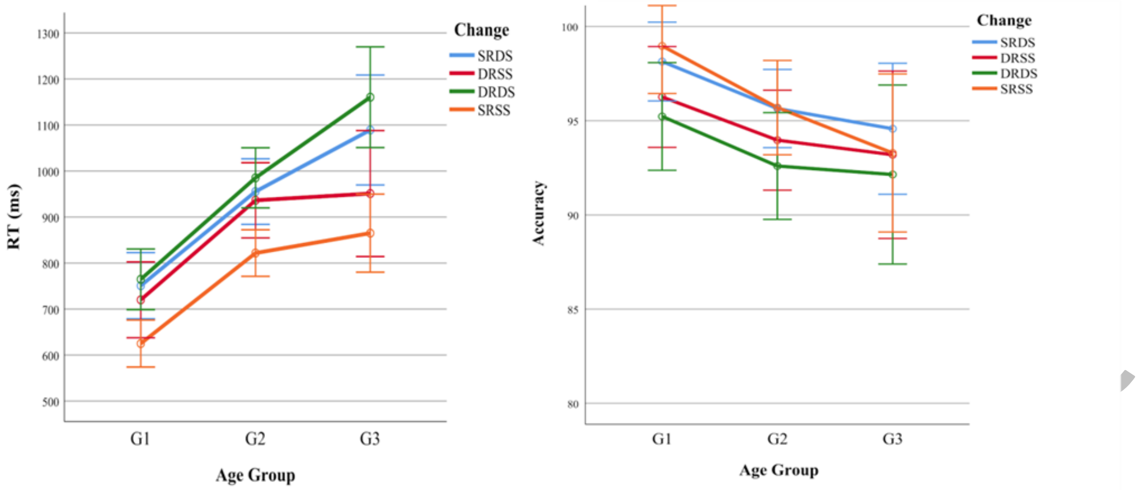

Figure 3. Reaction Time (RT) and Accuracy for the different conditions and Age Group. SRSS= Same Rule Same Site; SRDS = Same Rule Different Site; DRSS = Different Rule Same Site; DRDS= Different Rule Different Site. The bars represent the standard error.

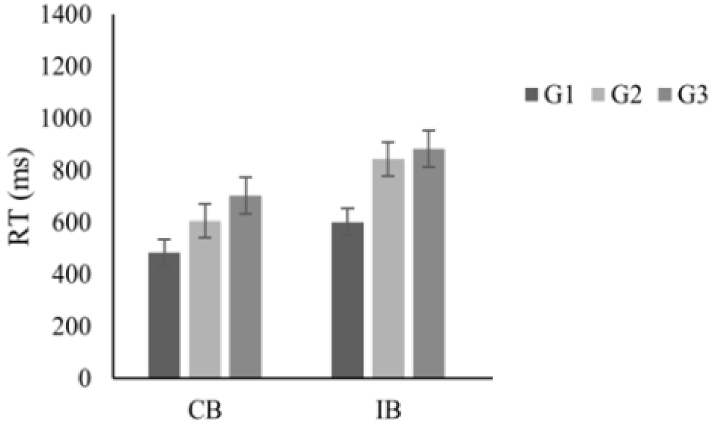

Figure 4. Reaction Time (RT) in Congruent Block (CB) and Incongruent Block (IB) for all age-groups. The bars represent the standard error.

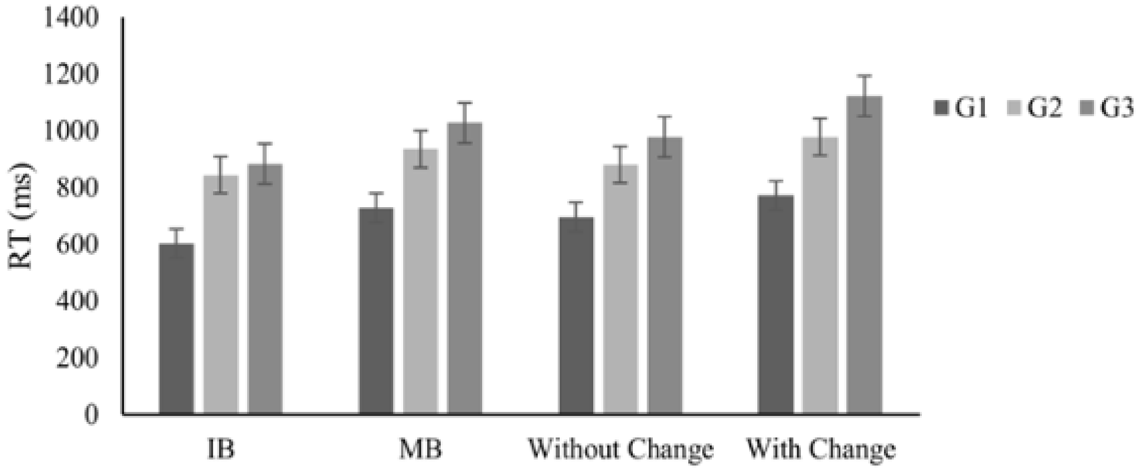

Figure 5. Reaction Time (RT) in Incongruent Block (IB), Mixed Block (MB) and in the conditions with and without change, for all age-groups. The bars represent the standard error.

Table 1

Summary of the measurement of the indexes in the three corollaries

Corollary/description	Condition/indicator	Measure
Corollary 1: it is always easier to change everything or change nothing than to change just one aspect.	Absence of change:	Is obtained from the average RT and the ACC in trials with no change of rule or response site in the trial immediately preceding it, in the mixed block.

	Partial change	Is obtained from the average RT and ACC in trials that require a rule change but not a response site change with respect to the preceding trial(DRSS) and in trials that require the same rule but a different response site (SRDS; see Figure 2).
	Total change	Is obtained from the average RT and ACC in trials where the rule and response site change with respect to the preceding trial
Corollary 2: It is easier to process the more salient aspects or attributes of an object or stimulus than just process some of its features.	CB	Is obtained from the average RT and ACC in trials where the stimuli are located at the same side of the correct response key (congruent trials).
	IB	Is obtained from the average RT and ACC in those trials where the stimuli are located at the opposite side of the correct response key (incongruent trials).
Corollary 3: It is easier to inhibit a dominant response all the time than it is to only sometimes.	IB	Is obtained from the average RT and ACC, in trials which the participant must inhibit the ipsilateral response in all IB trials.
	MB	It is obtained from the mean of RT and ACC, in trials in which the participant must inhibit the ipsilateral response in some of the trials (50% of total).

Note : MB mixed block; IB: incongruent block and CB: congruent block.

Table 2

Number of correct trials (0-1) in switch tasks, for different age groups.

Age Group	**Congruent Block M (SD)**	**Incongruent Block M (SD)**	**Mixed Block M (SD)**
G1: 40-59 (N=63)	0.99 (0.02)	0.89 (0.2)	0.94 (0.08)
G2: 60- 74 (N=61)	0.98 (0.04)	0.80 (0.2)	0.94 (0.09)
G3: 75-90 (N=23)	0.97 (0.05)	0.90 (0.09)	0.92 (0.09)

Table 3

Mean accuracy and mean RT under the different change conditions by group.

	Absence of change		**Partial change**		**Partial change**		**Total change**	
			SRDS		**DRSS**			
	RT	**ACC**	**RT**	**ACC**	**RT**	**ACC**	**RT**	**ACC**
G1	625(142)	0.98(0.04)	750(181)	0.98(0.04)	720(265)	0.96(0.08)	764(157)	0.95(0.01)
G2	821 (234)	0.95 (0.01)	955(308)	0.95(0.09)	936(361)	0.93(0.1)	985(270)	0.95(0.01)
G3	864 (208)	0.93 (0.01)	1089(384)	0.94 (0.01)	950 (313)	0.93 (0.1)	1160 (387)	0.92 (0.01)

Note: RT= Response Time; ACC= Accuracy; SRDS = Same Rule Different Site; DRSS = Different Rule Same Site.

Table 4

Correct responses mean ACC (0-1) y and mean RT (mls) in different blocks and conditions by group.

	CB		IB		MB					
					General performance		Trials without change		Trials with change	
	RT	ACC	RT	ACC	RT	ACC	RT	ACC	RT	ACC
G1	483(145)	0.99(0.02)	602(150)	0.92(0.01)	728(167)	0.96(0.05)	696(148)	0.96(0.05)	771(176)	0.56(0.3)
G2	606 (196)	0.99 (0.02)	844(301)	0.89 (0.01)	935(269)	0.94(0.09)	880(243)	0.96(0.08)	978(278)	0.59(0.3)
G3	703 (210)	0.98(0.03)	883.4(227)	0.93 (0.07)	1027(273)	0.93(0.09)	978(260)	0.95(0.08)	1122(366)	0.54(0.3)

Note: G1 = adults from 40 to 59 years (*M*=49.43; *SD*=6.23); G2 = Older adults from 60 to 74 years of age (*M*=67.32; *SD*=3.87); G3 = Older adults more than 74 years old (*M*=80.81; *SD*=6.05); RT= response time; CB= congruent block; IB=incongruent block.

Table 5

Differences between groups for different measures.

Comparison between blocks/measures		G1		G2		G3	
		RT	Accuracy	RT	Accuracy	RT	Accuracy
CB	IB	*p*<.001	*p*<.001	*p*<.001	*p*<.001	p<.001	ns
IB	MB	*p*<.001	ns	*p*<.001	ns	*p*<.001	ns
With / without change in MB		*p*<.001	*p*<.001	*p*<.001	*p*<.001	*p*<.001	*p*<.001

Note: G1 =; G2 =; G3 =; RT = Response time; ns = not significant; CB= congruent block; IB=incongruent block; MB= mixed block.

Table 6

Comparison by age: performance in different conditions.

Comparison		G1 ≠G2	G2≠G3	G1≠G3
CB-IB	RT	p<.001	ns	p<.001
(corollary 2b)	Accuracy	ns	ns	ns
IB-MB	RT	p<.001	ns	p<.001
(corollary 3b)	Accuracy	ns	ns	Ns
Change-without change, in MB	RT	p<.001	ns	p<.001
(corollary 3b)	Accuracy	ns	ns	ns

Note: G1 = adults from 40 to 59 years (*M*=49.43; *SD*=6.23); G2 = Older adults from 60 to 74 years of age (*M*=67.32; *SD*=3.87); G3 = Older adults more than 74 years old (*M*=80.81; *SD*=6.05); RT = Response Time; CB= congruent block; IB = Incongruent Block; MB=mixed block; ns= not significant. Post hoc comparison: Games Howell and Bonferroni.