



Field dependence–independence differently affects retrospective time estimation and flicker-induced time dilation

Alice Teghil^{1,2,3} · Maddalena Boccia³ · Cecilia Guariglia^{1,3}

Received: 4 October 2018 / Accepted: 29 January 2019 / Published online: 7 February 2019
© Springer-Verlag GmbH Germany, part of Springer Nature 2019

Abstract

Field dependence–independence (FDI) is a stable dimension of individual functioning, transversal to different cognitive domains. While the role of some individual variables in time perception has received considerable attention, it is not clear whether and how FDI influences timing abilities. In this study, we tested the hypothesis that FDI differently affects timing performance depending on whether the task requires cognitive restructuring. Participants were assessed for FDI using the embedded figures test (EFT). They performed a prospective timing task, reproducing the duration of a flickering stimulus, and a retrospective timing task, estimating the duration of the task. We expected performance of field-dependent (FD) and field-independent (FI) individuals not to differ in the prospective task, since restructuring of task material is not needed to reproduce the stimulus duration. Conversely, we predicted that FI individuals should be more accurate than FD ones in the retrospective condition, involving restructuring skills. Results show that while both FD and FI individuals under-reproduced the stimulus duration in the prospective task, only FD participants significantly underestimated the duration of the timing task in the retrospective condition. These results suggest that differences across FD and FI individuals are apparent in timing only when the task requires high-level cognitive processing; conversely, these differences do not affect basic sensory processing.

Keywords Time perception · Timing · Interval reproduction · Retrospective time estimation · Field dependence · Cognitive style

Introduction

The experience of time is one of the most central and distinctive features of humans' psychological life; indeed, the feeling of the flowing of time is intrinsic to our mental processing, and timing abilities are crucially involved in planning and performing actions towards the physical world. Research on timing and time perception has grown

considerably in recent years, leading to a better understanding of how the brain perceives and processes time. Among the different relevant lines of research, one important focus of investigation concerns the role of individual differences in timing; indeed, many studies have addressed the influence of sociodemographic and psychometric variables on time perception. Investigated variables include development (Droit-Volet 2013), aging (Block et al. 1998; Turgeon et al. 2016), gender (Block et al. 2000; Hayashi et al. 2013), expertise (Jantzen et al. 2014), general intelligence (Wearden et al. 1997; Haldemann et al. 2011), but also personality traits (Wittmann et al. 2011), and more broad dimensions of individual variability such as field dependence–independence (FDI) (Silverman et al. 1961; Du Preez 1967; Phillips 1977; Davidson and House 1978). Though the influence of FDI on cognitive functioning has received considerable attention during the 1960s and 1970s, from the 1980s onward a large part of research on FDI has focused on its educational and instructional implications. However, recent studies have highlighted the role of FDI in individual differences in complex cognitive processes (see, for example,

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s00221-019-05485-3>) contains supplementary material, which is available to authorized users.

✉ Alice Teghil
alice.teghil@uniroma1.it

¹ Department of Psychology, “Sapienza” University of Rome, via dei Marsi 78, 00185 Rome, Italy

² PhD Program in Behavioral Neuroscience, “Sapienza” University of Rome, Rome, Italy

³ Cognitive and Motor Rehabilitation Unit, IRCCS Fondazione Santa Lucia, via Ardeatina 306, 00179 Rome, Italy

Boccia et al. 2016, 2017a; Tascón et al. 2017), suggesting to further explore the influence of this dimension in other cognitive domains. FDI was defined by Witkin (1977) as “the information processing style characterizing the way an individual analyses the world, which is not affected by development, experience or learning” (Witkin 1977). While field-independent (FI) individuals usually rely upon an internal frame of reference, thus being able to avoid the influence of deceptive information coming from the external environment, field-dependent (FD) individuals tend to rely on an external frame of reference, and thus they are more easily misled by environmental deceptive cues (Witkin 1977). Though this difference was originally proposed with regard to the perceptual processing domain, FDI has been shown to represent a pervasive dimension of individual functioning (Berry et al. 1986), being related to differences in interpersonal behavior and in real-life educational and vocational choices (Witkin and Goodenough 1976a). Indeed, differences between FD and FI individuals have been reported in different cognitive domains, such as perceptual concept formation (Elkind et al. 1963), attentional functioning (Avolio et al. 1981), working memory (Goode et al. 2002), as well as, recently, in visuospatial processing and navigational skills (Boccia et al. 2016, 2017a), and long-term memory (Corson et al. 2009; Tascón et al. 2017); however, the relation of FDI to timing and time perception abilities is still unclear. Interestingly, in the early report by Silverman et al. (1961), FD participants were found to be more prone to under- or overestimate the duration of the experimental session compared to FI participants, though the authors did not provide information about the direction of the mean estimation error in the two groups (Silverman et al. 1961). However, this study assessed timing in sensory deprivation conditions, thus preventing the possibility to generalize results to retrospective time estimation in more ecological contexts. Following studies assessing the relationship of FDI to time perception yielded to contrasting evidence. Du Preez (1967) tested the hypothesis of a positive relationship between the degree of FI and the ability to “disembed” information about the duration of an interval from increasingly complex contexts. Participants interrupted the presentation of either an auditory signal, a music piece, a light, or a picture, to match the duration of a target interval (either defined by the same auditory signal or music piece). Weak-to-moderate or no correlations were found between measures of FDI and error scores in reproducing target intervals (1, 2 and 16 s), with no significant effect of content complexity, leading Du Preez to conclude that more complex sensory contexts did not embed temporal information to a greater extent than simpler ones. In a similar vein, Davidson and House (1978) asked FD and FI participants to reproduce 5 to 60-s intervals marked by flashes. To verify whether timing performance of FD individuals was more affected than that of FI participants

by variations in the surrounding field, the reproduction task was performed under different environmental conditions (slow ambient clicks, fast ambient clicks, no sound); no main effect of FDI and no FDI by environmental condition interaction were observed (Davidson and House 1978). Finally, Phillips (1977) assessed production of a 40-s interval in FI and FD individuals while in standing, sitting and lying position. The author hypothesized that mental activity should increase in FD participants more than in FI ones when changing from standing to sitting or lying positions, thus leading to an overestimation (i.e., an under-production) of time in the former compared to the latter group. No differences in produced durations were reported between FD and FI individuals, in either position, or in comparing the different postures. The author partly ascribed these results to possible methodological limitations in the FDI assessment procedure, and suggested that timing performance might be affected by the lack of control on the availability of kinesthetic cues and on vigilance levels while in lying position (Phillips 1977). Overall, this literature has thus provided contrasting evidence with regard to the influence of FDI on time perception, probably due to differences in tasks, experimental procedures, and research questions. On the one hand, the Du Preez (1967) and Davidson and House (1978) studies suggest that simply manipulating the sensory features of the stimulus/context during a timing task is not particularly effective in highlighting differences between FD and FI individuals. Similarly, Phillips (1977) provided evidence that accuracy in producing a specific time duration is not strongly affected by individual differences in processing kinesthetic cues. On the other hand, Silverman et al. (1961) highlighted differences between FD and FI individuals also manipulating the timing context (i.e., creating a sensory-deprived environment); however, at variance with the abovementioned studies, perceived time was assessed retrospectively (Silverman et al. 1961). In this vein, notably one variable that may have affected the abovementioned results is the degree of cognitive restructuring imposed by the specific timing task. Indeed, Witkin (1977) originally suggested that individual variability along the FDI continuum only affects tasks in which cognitive restructuring is required, that is tasks in which an individual has to act on the field, going beyond the information provided (Witkin 1977; Witkin and Goodenough 1976b). Cognitive restructuring is assumed to be involved in tasks in which the field lacks an inherent structure, in tasks requiring a re-organization of the material, and in those in which an organized field has to be “broken” to extract discrete elements (Witkin 1977). Typically, FI individuals show better restructuring abilities than FD ones, since their internal frame of reference allows them to effectively restructure the field when needed; conversely, performance in tasks not requiring cognitive restructuring is affected just weakly or not at all by differences in FDI

(Witkin 1977). In line with these reports, Boccia et al. (2017a, b) have recently shown that individual predisposition towards FDI does not generally affect navigational skills, but rather modulates performance in navigational tasks depending on whether cognitive restructuring processes are involved. Indeed, the degree of FDI has been found to predict the ability to create a map-like representation of the environment, a task requiring to re-organize the navigational field to create an allocentric representation of places and their spatial relations (Boccia et al. 2017a). Conversely, predisposition towards FDI does not apparently affect navigational tasks in which restructuring is not required, such as landmark recognition and ordering (Boccia et al. 2017b).

One intriguing possibility is thus that individual predisposition towards FDI differently affects timing performance depending on whether the task involves cognitive restructuring or not. Different types of timing paradigms differ substantially in the degree to which complex cognitive manipulations of the material are required to solve the task. At one end of the continuum, many prospective timing tasks require participants to decide which of two temporal intervals is longer (duration discrimination), or to reproduce a duration presented earlier (duration reproduction). In a typical duration reproduction task, participants encode in working memory the duration of a reference stimulus at the beginning of the trial; then, in the reproduction phase, they make a response when they think that a second stimulus has lasted as long as the reference one. In this kind of paradigm, encoding the duration of the reference stimulus and timing the duration of the comparison stimulus do not require restructuring of temporal information, since information is already structured and provided in the form needed to perform the task. In other words, similarly to what happens during landmark recognition or multiple-choice lexical tasks (Boccia et al. 2017b; Elkind et al. 1963), in standard duration reproduction there is no need to reorganize or reinterpret the material of the task, because information about duration of the stimuli is easily available without the need of reconfiguring or rearranging the inputs.

However, at the other end of the continuum, tasks requiring a retrospective estimate of time likely involve cognitive restructuring processes. Retrospective timing paradigms usually require participants to estimate how long a task, an event, or sometimes the whole experimental session has lasted. In these paradigms, the estimate is typically provided only one time at the end of the trial/experimental session, and participants do not know in advance that they will be asked to provide the judgment (Block and Zakay 1997; Grondin and Laflamme 2015; Block and Gruber 2014). The ability to retrospectively estimate time is generally thought to depend on memory processes, possibly involving the retrieval of contextual changes occurred during the period

which duration has to be estimated (Block 1990; Zakay et al. 1994). It has been proposed indeed that temporal features of events, together with temporal relations between events, are encoded as parts of memories for the events themselves (Block 1990); retrospective time estimation should thus be the result of cognitive construction processes (Zakay and Block 2004), likely entailing the restructuring of memories of occurred events to extract their temporal features. In this type of task, indeed, information about the duration and temporal attributes of events is not explicitly encoded and thus immediately available, but rather it has to be actively reconstructed through the re-arrangement of event memories.

In this vein, in the present study we aimed at assessing whether individual variability along the FDI dimension selectively affects timing performance when cognitive restructuring is required. To this aim, we used the embedded figures test (EFT) (Witkin et al. 1971) to assess individual predisposition towards FDI in a sample of healthy participants. We also developed a prospective temporal reproduction task, requiring to reproduce the duration of a previously presented stimulus, and assessed participants' retrospective estimation of task duration. Since temporal reproduction does not entail high restructuring demands, we expected that performances of FD and FI individuals should not differ significantly in this task. Conversely, we predicted that retrospective timing performance would differ between FD and FI participants, being FI individuals more efficient in extracting temporal information from memory, and thus being able to estimate elapsed time with higher accuracy than FD participants. In other words, since having higher restructuring skills should provide an advantage in re-organizing encoded memories of events according to their temporal features, we expected that estimates provided by FI participants should deviate from actual durations less than those provided by FD participants.

Materials and methods

Participants

40 healthy participants (mean age 26.17, $SD = 3.51$; 20 females) took part in the study. None of the participants had a history of neurological or psychiatric disease, which was confirmed during an informal interview carried out before the test phase. All participants were right-handed and had normal or corrected-to-normal vision. The study was designed in accordance with the principles of the Declaration of Helsinki and was approved by the ethical committee of Fondazione Santa Lucia, Rome. Informed consent was obtained from all individual participants included in the study.

Assessment of FDI

Predisposition towards FDI is classically assessed through tasks requiring to locate simple geometric shapes embedded in more complex configurations (Witkin et al. 1971). FI individuals are typically able to ignore contextual information and outperform FD individuals (which are more affected by the contextual organization of the figure) in locating the simple shapes. In this study, participants were assessed for FDI using the embedded figures test (EFT) (Witkin et al. 1971). Test material consists in two sets of 12.9×7.7 cm cards, on which simple shapes (8 cards) and complex figures (12 cards) are printed. The task requires participants to find a simple shape within a more complex configuration, trying to locate the simple shape as quickly as possible. On each trial, the examiner shows the participant one complex figure for 15 s, then he/she hides the card and shows one of the simple shapes for 10 s. After this time has elapsed, the experimenter removes the simple shape, and presents the complex figure again. For each item, the time required to correctly locate the simple shape is written down and converted in seconds; if the participant is unable to correctly locate the simple shape within 3 min, the item is scored as wrong and it is given a score of 180 s. Individuals' score corresponds to the overall average solution time for the 12 test trials. Thus, lower EFT scores correspond to greater predisposition towards FI, whereas higher EFT scores are indicative of stronger predisposition towards FD.

Prospective temporal reproduction task

A computerized task was developed to assess participants' prospective temporal reproduction performance. We presented a green (RGB 0/1/0) asterisk, flickering at the center of a black background. Participants were instructed to reproduce the duration of the asterisk. A single trial started with the presentation of a fixation cross, lasting 1000 ms, at the center of the screen. Next, in the encoding phase, the stimulus was presented for either 4200, 5600, 7000, 8400, 9800 or 11,200 ms. Right after the encoding phase, the starting of the reproduction phase was marked by the presentation of the word "Reproduce" at the center of the screen, for 1000 ms. Then, the stimulus was presented again, and participants were instructed to interrupt its presentation by a spacebar press when they thought the same time as the encoding phase was elapsed. In the encoding phase, the stimulus flickered at a fixed frequency of 1.43 Hz. In the reproduction phase, the flickering frequency of the stimulus was either 0.87, 1, 1.18, 1.43, 1.8, 2.5 or 4 Hz. Each duration was presented 12 times, for a total of 72 trials. In half of the trials, the flickering frequency of the stimulus in the reproduction phase was the same as in the encoding phase (1.43 Hz). To prevent participants from relying on the number of flickering cycles

to perform the task, in the remaining 36 trials the flickering frequency of the stimulus in the reproduction phase was varied between 0.87, 1, 1.18, 1.8, 2.5 or 4 Hz (catch trials). Thus, each duration was presented six times with a flickering frequency fixed between encoding and reproduction phase (experimental trials), and six times with a flickering frequency different between encoding and reproduction phase (one trial for each different frequency used in the reproduction phase). The order of catch and experimental trials was randomized across participants as follows: 4 lists of 72 trials were created and divided in 2 blocks of 36 trials. Randomization lists, as well as the presentation order of the two blocks within each randomization list, were counterbalanced across participants. Prior to the experimental task, all participants went into a short familiarization session (six trials) with the same structure of the task. In the familiarization session, the stimulus was presented for either 3600, 4500, 5400, 6300, 7200 or 8100 ms; the flickering frequency was fixed at 2.2 Hz in the encoding phase, and varied between 1.11 Hz, 2.2 Hz, 3.33 Hz, and 5 Hz in the reproduction phase (three trials with same and three trials with different flickering frequency between encoding and reproduction). Stimuli were generated and presented on a laptop using the Cogent Toolbox (Cogent, <http://www.vislab.ucl.ac.uk/Cogent/>) for MATLAB (Mathworks).

Retrospective time estimation task

To assess participants' retrospective time estimation ability, a retrospective duration estimate was requested two times during the experimental session. After completion of each of the two blocks of the temporal reproduction task, the experimenter asked the question: "How long do you think this computerized task has lasted?". Thus, each participant underwent two retrospective time estimation trials. The experimenter took note of the participant's verbal estimates, and registered the total clock time provided by the Cogent MATLAB script at the end of each block.

Procedure

Participants performed the EFT, the temporal reproduction task and the retrospective time estimation task in a single session, lasting ~ 1 h. They were tested individually in a quiet, well-lit room. No clock was available during the experimental session and participants wearing a watch were asked to remove it at the beginning of the session. The administration order of the EFT and of the two blocks of the temporal reproduction task was counterbalanced across participants.

Results

Statistical analyses were performed using SPSS (IBM SPSS Statistics 24). Participants were divided into FI and FD using a median-split of EFT scores (averaged solution times). Thus, participants with lower scores than the median (31.12) were classified as FI, while participants whose scores were higher than the median were classified as FD. A Chi-square test revealed that the proportion of females and males was not significantly different in the FI and FD groups ($\chi^2=1.6, p=0.206$). Also, females and males did not differ in averaged solution times ($t(38)=1.819; p=0.077$, two-tailed). Mean age of participants was not significantly different in the FI (mean = 25.6, SD = 2.58) and FD (mean = 26.75, SD = 4.23) groups ($t(38)=-1.04, p=0.306$, two-tailed).

Prospective temporal reproduction task

The mean reproduced duration in the experimental trials (i.e., both encoding and reproduction 1.43 Hz condition) was calculated for each target duration (3600, 4500, 5400, 6300, 7200, 8100 ms). Analyses were then performed on mean reproduced durations, on the variability (SD) of reproduced durations, and on the degree of deviation of reproduced durations from target durations (standardized error, calculated as reproduced duration – target duration/target duration). None of the abovementioned indices was found to be affected by Gender differences, thus this factor was excluded from further analyses (results of analyses on Gender effects are provided in Supplementary Materials). An ANOVA on mean reproduced duration was performed with Group (FD vs. FI) as between-subject factor and Interval Duration (3600, 4500, 5400, 6300, 7200, 8100 ms) as within-subject factor. Mauchly’s test was used to test

sphericity for repeated measures; when a departure from sphericity was detected we adopted a Greenhouse–Geisser’s correction. We found a significant main effect of Interval Duration ($F(3.286, 124.886) = 1050.735, p < 0.001, \eta_p^2 = 0.965$), but no significant effect of Group ($F(1, 38) = 0.615, p = 0.438, \eta_p^2 = 0.016$) or Interval Duration \times Group interaction ($F(3.286, 124.886) = 2.19, p = 0.087, \eta_p^2 = 0.054$). The different target durations were thus discriminated effectively by participants in both the FD and FI group (Fig. 1a). We also performed an ANOVA on the SD of reproduced durations (Fig. 1b), with Group (2) and Interval Duration (6). Mauchly’s test was used to test sphericity for repeated measures; when a departure from sphericity was detected we adopted a Greenhouse–Geisser’s correction. The ANOVA showed a significant effect of Interval Duration ($F(3.813, 144.844) = 7.549, p < 0.001, \eta_p^2 = 0.166$), and no effect of Group ($F(1, 38) = 0.003, p = 0.956, \eta_p^2 < 0.001$) or Interval Duration \times Group interaction ($F(3.813, 144.844) = 1.165, p = 0.328, \eta_p^2 = 0.030$). Thus, the variability of reproduction times increased with target duration in both the FD and the FI groups. Finally, we performed an ANOVA on standardized errors, with Group as between-subjects factor and Interval Duration as within-subjects factor. We found no significant effect of Duration ($F(5, 190) = 2.141, p = 0.062, \eta_p^2 = 0.053$), Group ($F(1, 38) = 0.188, p = 0.667, \eta_p^2 = 0.005$), or Interval Duration \times Group interaction ($F(5, 190) = 1.641, p = 0.151, \eta_p^2 = 0.041$). As shown in Fig. 1c, all durations were under-reproduced, with a comparable degree of under-reproduction across the FD and the FI groups; in both groups, the degree of deviation from the target durations was significantly different from zero (all $t > -2.838$, with $p < 0.01$, two-tailed).

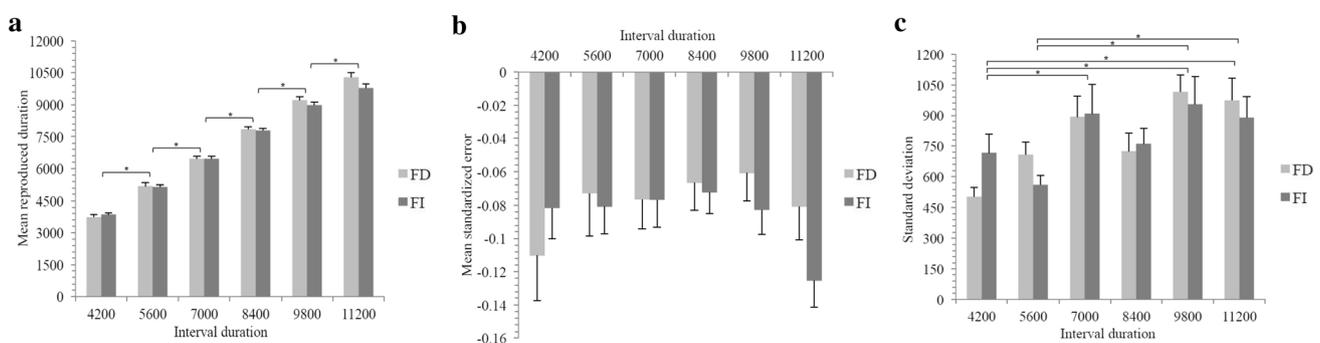


Fig. 1 Results of the prospective temporal reproduction task. **a** Mean reproduced duration (ms) for each target duration in the field-dependent (FD) and field-independent (FI) group (error bars represent standard errors). Significant differences are marked with an asterisk. **b** Mean standard deviation of reproduced duration for each target duration in the field-dependent (FD) and field-independent (FI)

group (error bars represent standard errors). Significant differences are marked with an asterisk. **c** Mean standardized error of reproduced duration for each target duration in the field-dependent (FD) and field-independent (FI) group (error bars represent standard errors). Significant differences are marked with an asterisk

Retrospective time estimation task

We compared actual and estimated durations of the two blocks of the temporal reproduction task, as well as the ratios of estimated-to-actual durations, between FD and FI individuals. Similarly to the temporal reproduction task, no significant Gender difference was found in these measures, and thus this factor was not further considered in subsequent analyses (results of analyses on Gender are reported in Supplementary Materials). We first compared the mean actual duration of the two blocks of the temporal reproduction task across the FD and FI groups. Due to technical issues during data collection, this information was not available for one FI participant in both blocks, and for one FD participant in the second block; thus, the following analyses were performed on 38 participants. The mean actual duration in the FD group was 870.25 (72.5) s for the first performed block, and 849.26 (38.3) s for the second block. In the FI group, the mean duration of the first and the second block was, respectively, 874.89 (127.01) and 847.56 (46.5) s. An ANOVA with Group (FD vs. FI) as between-subject factor and Block (First, Second) as within-subject factor showed no significant effect of Group ($F(1, 36) = 0.006$, $p = 0.938$, $\eta_p^2 < 0.001$), Block ($F(1, 36) = 1.919$, $p = 0.175$, $\eta_p^2 = 0.051$), or their interaction ($F(1, 36) = 0.033$, $p = 0.857$, $\eta_p^2 = 0.001$). Thus, the mean duration of the reproduction task was comparable across the two blocks and across the FD and FI groups. The same ANOVA was then performed on verbal estimates of the duration of the two task blocks. We found no significant effect of Block ($F(1, 36) = 0.178$, $p = 0.675$, $\eta_p^2 = 0.005$), and Block \times Group interaction ($F(1, 36) = 0.004$, $p = 0.952$, $\eta_p^2 < 0.001$); however, the main effect of Group was significant ($F(1, 36) = 5.918$, $p = 0.020$, $\eta_p^2 = 0.141$), with verbal estimates provided by participants in the FD group being significantly shorter than those provided by participants in the FI group. *T* tests comparing actual and estimated durations of the two blocks in the two groups showed that verbal estimates of FD participants were significantly different from actual durations (first block: $t(18) = 2.238$, $p = 0.038$, two-tailed; second block: $t(18) = 2.691$, $p = 0.015$, two-tailed), while verbal estimates of FI participants were not (first block: $t(18) = -1.100$, $p = 0.286$, two-tailed; second block: $t(18) = -0.935$, $p = 0.362$, two-tailed). We then performed an ANOVA on the ratio of estimated-to-actual durations for the two blocks, with the factors Group (FD vs. FI) and Block (First, Second). We found a significant effect of Group ($F(1, 36) = 5.817$, $p = 0.021$, $\eta_p^2 = 0.139$), and no significant effect of Block ($F(1, 36) < 0.001$, $p = 0.982$, $\eta_p^2 < 0.001$) or Block \times Group ($F(1, 36) < 0.001$, $p = 0.985$, $\eta_p^2 < 0.001$), showing that the ratio of estimated-to-actual

durations was different between FD and FI groups. Indeed, the estimated/actual duration ratio was significantly different from 1 for both blocks in the FD group (*t*-test for the first block: $t(19) = -2.207$, $p = 0.040$, two-tailed; *t*-test for the second block: $t(18) = -2.654$, $p = 0.016$, two-tailed), but not in the FI group (*t*-test for the first block: $t(18) = 1.233$, $p = 0.233$, two-tailed; *t*-test for the second block: $t(18) = 0.950$, $p = 0.354$, two-tailed), showing that only FD participants provided estimates of elapsed time significantly different (shorter) than actual durations.

It is worth noting that, since a retrospective estimate of elapsed time was required twice (see “Materials and methods”), participants probably became aware of the need to pay attention to time after providing the first estimate. Since the first trial provides a more reliable measure of time estimation in retrospective conditions, we repeated analyses focusing on the retrospective duration estimate of the first block of the reproduction task only. Mean actual duration of the first block of the temporal reproduction task did not differ across FD (872.83 s, SD = 71.51) and FI individuals (874.89 s, SD = 127.01) ($t(37) = 0.063$, $p = 0.950$, two-tailed). Conversely, verbal estimates provided by FD participants were significantly shorter (711.00 s, SD = 308.577) than those provided by FI participants (966.32 s, SD = 345.193) ($t(37) = 2.438$, $p = 0.020$, two-tailed). Mean estimated block duration was significantly different from actual duration in FD ($t(19) = -2.245$, $p = 0.037$, two-tailed) but not in FI participants ($t(18) = 1.100$, $p = 0.286$, two-tailed). Figure 2a shows the mean estimated duration of the task block in the FD and FI groups. The estimated/actual duration ratio was significantly different between the two groups, ($t(37) = 2.384$, $p = 0.022$, two-tailed), being different from 1 in the FD group ($t(19) = -2.207$, $p = 0.040$, two-tailed), but not in the FI group ($t(18) = 1.233$, $p = 0.233$, two-tailed) (Fig. 2b).

Correlation between FDI and timing measures

To investigate whether there was a relation between the degree of FDI and the degree of under/over estimation of durations in the prospective and the retrospective timing tasks, we performed two-tailed Spearman’s correlations between EFT scores, mean standardized errors of prospectively reproduced durations, and estimated/actual duration ratio scores in the first trial of the retrospective task, across the whole sample of participants. No significant correlation was observed between EFT scores and prospective timing measures, or between prospective and retrospective measures of time perception. However, we found a significant negative correlation between EFT scores and estimated/actual duration ratio scores in the retrospective task ($r_s = -0.319$, $p = 0.048$, two-tailed), suggesting that higher EFT scores (i.e., a stronger predisposition towards

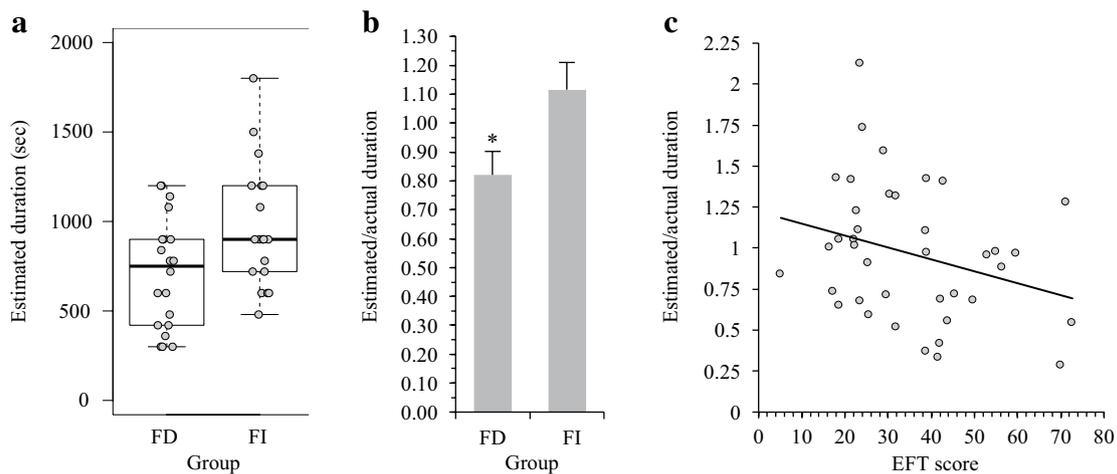


Fig. 2 Results of the retrospective time estimation task. **a** Estimated duration of the first block of the temporal reproduction task in the field-dependent (FD) and field-independent (FI) group. **b** Estimated/actual duration ratio for the first block of the reproduction task in the

field-dependent (FD) and field-independent (FI) group (error bars represent standard errors). Significant differences are marked with an asterisk. **c** Correlation between EFT scores and estimated/actual duration ratio for the first block of the temporal reproduction task

FD) correspond to a disposition to underestimate elapsed time (Fig. 2c).

Discussion

Here we tested the hypothesis that individual predisposition towards FDI differently affects timing depending on whether the task at hand requires cognitive restructuring. To this aim, we assessed FDI in a sample of healthy participants using the EFT. Participants also performed two timing tasks, namely a *prospective temporal reproduction task*, in which they reproduced a target duration presented immediately before the reproduction phase, and a *retrospective time estimation task*, in which they judged the duration of the reproduction task right after completion. We will first discuss results of the temporal reproduction task.

Performance in the temporal reproduction task was found not to differ significantly between FD and FI participants; indeed, mean reproduced durations and variability of reproduced durations were comparable across the FD and FI groups, increasing with target durations in both groups. The analysis of the degree of deviation of reproduced durations from target durations (standardized error) showed that participants in both groups significantly under-reproduced target durations. It is interesting to note that perceived durations in this task may have been affected by the visual features of the presented stimuli. Literature suggests that the apparent duration of visual stimuli may be influenced by a number of variables, including those related to movement and temporal frequency (Lhamon and Goldstone 1975; Brown 1995; Plomp et al. 2012). Flickering stimuli, in particular, have

been shown to be perceived as longer than static stimuli with the same physical duration (time dilation effect) (Kanai et al. 2006; Lhamon and Goldstone 1975; Herbst et al. 2013, 2015). Since the stimulus to be reproduced in our task was a flickering asterisk, the under-reproduction of durations in the present study likely reflects a flicker-induced dilation of perceived stimulus duration. Though the discussion of neural mechanisms involved in flicker-induced temporal illusions is beyond the scopes of the present work, the under-reproduction of target durations observed in the present study notably occurred to the same degree in the FD and in the FI group. The finding that this effect seems to be little affected by a dimension of individual variability in high-level cognitive functioning such as FDI is thus in line with the body of literature suggesting that temporal illusions of this sort may be the result of relatively automatic sensory-level processes (Johnston et al. 2006; Kaneko and Murakami 2009; Linares and Gorea 2015; Okajima and Yotsumoto 2016; Hashimoto and Yotsumoto 2018).

At difference with the temporal reproduction task, the retrospective time estimation task highlighted some remarkable differences across performance in the FD and the FI groups. Indeed, though the duration to be estimated was not different across FD and FI participants, FD individuals as a group significantly underestimated the duration of the task. This effect was not present in the FI group, in which retrospective estimate of the block duration did not significantly differ from its actual duration. Analysis of the estimated/actual duration ratio of retrospective estimates further revealed that the degree to which the estimates deviated from actual durations was significantly different from one in the FD group only. Results of the retrospective time estimation task thus

show that, while FI individuals as a group provided overall accurate estimates of elapsed block time, FD ones were less accurate, significantly underestimating the elapsed time. Also, EFT scores were found to be negatively correlated with estimated-to-actual duration ratio scores in the retrospective task, further suggesting that FD participants tend to underestimate elapsed time. This latter result should be taken cautiously due to the relatively small sample size for correlation; however, since the degree of FDI as assessed through the EFT is a continuous measure, correlation analyses allow to better characterize the relation between predisposition towards FDI and retrospective time estimation. The finding of superior retrospective timing abilities in the FI compared to the FD group is thus in line with our predictions, and fits well with the hypothesis that this advantage results from having higher cognitive restructuring skills. One key feature in retrospective time judgments is that the individual is not aware of the importance of paying attention to time until he/she is asked to provide the judgment. Since elapsing time is unattended during the task, retrospective time estimation is thus generally thought to involve memory mechanisms (Michon 1972; Block 1974; Block and Zakay 1997; Grondin and Laflamme 2015). As mentioned in “Introduction”, one of the most influential theories on retrospective timing—namely the “contextual-change model” (Block 1978, 1990; Block and Reed 1978; Zakay et al. 1994; Zakay and Block 2004; Block and Gruber 2014)—posits that retrospective judgments of time are based on a cognitive reconstruction involving the retrieval of contextual changes occurred during the interval which duration has to be estimated; thus, the more contextual changes are retrieved, the longer the time period is judged (Block 1990). Contextual information of this sort includes changes in cognitive, emotional as well as environmental context, and it is coded largely automatically together with other features of event memories (Block 1990; Zakay and Block 2004); the retrospective estimation of a time interval is thus basically accomplished through episodic remembering processes (Zakay and Block 2004). In this vein, the present results may be explained assuming that FD participants encoded and/or retrieved a lower number of contextual changes compared to FI ones. Notably, this interpretation suggests that FD participants, compared to FI ones, recollected a smaller number of memories of events occurred during the temporal reproduction task. Literature on the relation between FDI and long-term memory performance seem to suggest that FD individuals perform worse than FI ones in free-recall tasks when the items to be recalled lack an intrinsic organization (Goodenough 1975; Spiro and Tirre 1980); however, to the best of our knowledge, episodic recollection abilities have not been investigated in the context of individual differences in FDI. Interestingly, using a Deese–Roediger–McDermott paradigm, Corson et al. (2009) found that FI participants were less likely than FD ones to

recall “critical lures”, suggesting that their resistance to memory distortions may be due to the tendency to separate the studied words from their activated context (Corson et al. 2009). One intriguing possibility is thus that the advantage reported by FI participants in our retrospective time estimation task reflects not as much an accurate recollection of the number of occurred events, but rather a superior proficiency in extracting contextual and/or temporal information from the surrounding context within events memories. In this vein, the higher cognitive restructuring skills of FI participants may have allowed them to restructure recollected event memories to separate relevant contextual and temporal information from other, irrelevant information encoded within a memory trace. Notably, Brunec et al. (2017) have recently shown that temporal features concerning duration of events can be encoded incidentally within event memories, and that the ability to access these temporal features is dependent on the recollection of events themselves. This report is in line with suggestions that retrospective time estimation correlates with “Remember” responses in a Remember/Know paradigm (El Haj et al. 2013). Though participants of both the FD and FI groups were most likely able to recollect memories of internal and external events occurred during the to-be-estimated interval, it is thus possible that cognitive restructuring skills characterizing FI individuals have provided them of a specific advantage in flexibly selecting and reorganizing relevant (temporal and not temporal) details of event memories.

Overall, present results support the hypothesis that FDI differentially affects timing performance depending on whether cognitive restructuring skills are involved; FD and FI participants did not differ for either length, variability or degree of deviation of their time estimates when the task at hand did not require complex processing of material, and temporal information could be simply inferred at a sensory-processing level. Conversely, differences between FD and FI participants in timing performance became apparent when the task required to go beyond information provided, restructuring this information to extract its temporal meaning. The finding that FDI does not affect timing abilities in general, but rather interacts with the degree of cognitive restructuring required by the task in explaining individual differences in timing performance, may help understanding the somehow inconclusive results on the relation between FDI and time perception provided by previous literature. On the one hand, our results fit well with those by Silverman et al. (1961). In this vein, it is conceivable that participants in the Silverman et al. study were forced to rely mainly on internal (interoceptive, emotional etc.) contextual and temporal cues in order to retrospectively estimate the duration of the experimental session; however, the report of higher accuracy in FI participants is in line with the hypothesis that this kind of task requires restructuring recollected event memories,

be them of internal of external events. On the other hand, present results are also consistent with those of the Du Preez (1967) and the Davidson and House (1978) studies; indeed, assuming that differences in FDI affect timing only when cognitive restructuring is required, there is no evidence that changing the type of material defining a temporal interval or varying ambient conditions in which the task is performed forces the individual to restructure the context. Similarly, no complex manipulation and/or reorganization of task material was required in the Phillips (1977) study, since interval production basically involves the translation of a specifically labeled time interval into a subjective duration (Mioni et al. 2014).

There is one important caveat to our results. It is common opinion that the main feature of retrospective timing tasks is that participants must be unaware of the need to track the passage of time (Grondin and Laflamme 2015; Block and Gruber 2014; Block and Zakay 1997; Matthews and Meck 2016), because once they know that time is a concern, the task becomes prospective in nature (Block and Zakay 1997; Tobin et al. 2010). In the present study, the interval to be retrospectively estimated was filled with a timing task (prospective temporal reproduction), and thus participants were arguably attending to time since the beginning of the experimental session. However, we believe that this does not invalidate our retrospective timing results. Indeed, though it may be true that participants were attending to time, judgments of long durations are unlikely to simply result from adding together durations of individual events (Droit-Volet et al. 2018), and it is implausible to our opinion that participants were able to create an estimate of a ~ 15 min duration based on their cumulative experience of the time elapsed during each of the 75 temporal reproduction trials.

Another limitation of the present study is that a single FDI measure—i.e., the EFT score—was used. Assessing FDI through different tests would improve the reliability of the classification of participants as either FD or FI. In this vein, classification of individuals in the two groups may possibly have benefited from including an FDI test not strongly relying on visuo-constructive skills, such as the body-adjustment test (BAT) (Witkin 1949). However, we find it unlikely that retrospective timing differences we highlighted may be artifactually related to the specific kind of FDI test employed. Indeed, since our retrospective time estimation task did not involve any visual or spatial component, the more accurate estimates provided by participants classified as FI are unlikely to simply arise from their better visual disembedding skills. A more plausible explanation is thus that differences between FD and FI participants in retrospective time estimation reflect differences along a more high-level dimension of variability, such as cognitive restructuring. Supporting this interpretation, previous studies in which no differences were found between FD and FI individuals also

assessed FDI through tasks other than the EFT, e.g., the rod and frame test (RFT) (Du Preez 1967; Phillips 1977). Finally, our retrospective timing results are consistent with those of Silverman et al. (1961), which assessed FDI through both the Draw-A-Person test scored by the Short Scale of Body vs. Field Orientation, and the RFT (Silverman et al. 1961). Thus, we believe that our results are indicative of actual differences in retrospective time estimation between participants having higher or lower cognitive restructuring skills, rather than being biased by the type of FDI test employed.

Though present results are consistent with the hypothesis that differences between FD and FI individuals may be specifically observed in time perception when the tasks involve cognitive restructuring, it has to be noted that our experimental design does not completely allow to rule out alternative explanations. In this vein, one possibility is that the observed difference between FD and FI participants is specific to retrospective vs. prospective timing paradigms. Results from the comparison between the first and the second retrospective timing estimate, however, come out against such a possibility. If our findings were solely driven by the fact that duration information was intentionally encoded during one task, but not during the other, no differences should have been highlighted between groups in the second retrospective time estimation trial, since participants likely anticipated being asked again about duration of the task. The finding of a similar pattern in the two time estimation trials suggests that the key variable in determining whether there will be differences in timing between FD and FI individuals is not simply the prospective vs. retrospective nature of the task. Similarly, another drawback of our study is that two different methods, i.e., reproduction and verbal estimation, were used to probe time perception in the low vs. high restructuring condition. A replication on these results using the same method across the two conditions would be advisable to allow drawing stronger conclusions on differences between FD and FI individuals.

Conclusions

Taken together, our results suggest that the influence of a dimension of high-level cognitive variability such as FDI on time perception depends on the type of timing task at hand, with more sensory-grounded tasks being unaffected by variations along this dimension, and more complex tasks involving cognitive restructuring of information revealing differences in performance according to the degree of FDI. Further studies will be needed to clarify whether the differential influence of FDI on timing performance in prospective vs. retrospective conditions can be generalized to other kinds of prospective and retrospective timing paradigms, or

it depends more strictly on the particular features of the timing task at hand. In this vein, an interesting extension to the present results should be probing performance of FD and FI individuals in more closely matched prospective and retrospective conditions (see, for example, Brown and Stubbs 1988; Grondin and Plourde 2007; Tobin et al. 2010), allowing to integrate the present study to better characterize the influence of individual variables on time perception.

Acknowledgements The present study was partially supported by funding from Sapienza University of Rome to AT (Avvio alla Ricerca, 2018; nr AR11816421D63BF2) and by fellowship from the PhD Program in Behavioral Neuroscience of Sapienza University of Rome to AT.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

- Avolio BJ, Alexander RA, Barrett GV, Sterns HL (1981) Designing a measure of visual selective attention to assess individual differences in information processing. *Appl Psychol Meas* 5:29–42
- Berry JW, van de Koppel JMH, Sénéchal C, Annis RC, Bahuchet S, Cavalli-Sforza LL, Witkin HA (1986) On the edge of the forest. Cultural adaptation and cognitive development in Central Africa. Swets & Zeitlinger B.V., Lisse
- Block RA (1974) Memory and the experience of duration in retrospective. *Mem Cognit* 2:153–160. <https://doi.org/10.3758/BF03197508>
- Block RA (1978) Remembered duration: effects of event and sequence complexity. *Mem Cognit* 6:320–332. <https://doi.org/10.3758/BF03197462>
- Block RA (1990) Models of psychological time. In: Block RA (ed) *Cognitive models of psychological time*, 1st edn. Psychology Press, New York, pp 1–36
- Block RA, Gruber RP (2014) Time perception, attention, and memory: a selective review. *Acta Psychol (Amst)* 149:129–133. <https://doi.org/10.1016/j.actpsy.2013.11.003>
- Block RA, Reed MJ (1978) Remembered duration: evidence for a contextual-change hypothesis. *J Exp Psychol Hum Learn* 4:656–665. <https://doi.org/10.1037/0278-7393.4.6.656>
- Block RA, Zakay D (1997) Prospective and retrospective duration judgments: a meta-analytic review. *Psychon Bull Rev* 4:184–197. <https://doi.org/10.3758/BF03209393>
- Block RA, Zakay D, Hancock PA (1998) Human aging and duration judgments: a meta-analytic review. *Psychol Aging* 13:584–596
- Block RA, Hancock PA, Zakay D (2000) Sex differences in duration judgments: a meta-analytic review. *Mem Cognit* 28:1333–1346
- Boccia M, Piccardi L, Di Marco M, Pizzamiglio L, Guariglia C (2016) Does field independence predict visuo-spatial abilities underpinning human navigation? Behavioural evidence. *Exp Brain Res* 234:2799–2807. <https://doi.org/10.1007/s00221-016-4682-9>
- Boccia M, Piccardi L, D'Alessandro A, Nori R, Guariglia C (2017a) Restructuring the navigational field: individual predisposition towards field independence predicts preferred navigational strategy. *Exp Brain Res* 235:1741–1748. <https://doi.org/10.1007/s00221-017-4936-1>
- Boccia M, Vecchione F, Piccardi L, Guariglia C (2017b) Effect of cognitive style on learning and retrieval of navigational environments. *Front Pharmacol* 8:496. <https://doi.org/10.3389/fphar.2017.00496>
- Brown SW (1995) Time, change, and motion: the effects of stimulus movement on temporal perception. *Percept Psychophys* 57:105–116
- Brown SW, Stubbs DA (1988) The psychophysics of retrospective and prospective timing. *Perception* 17(3):297–310. <https://doi.org/10.1068/p170297>
- Brunec IK, Ozubko JD, Barense M, Moscovitch M (2017) Recollection-dependent memory for event duration in large-scale spatial navigation. *Learn Mem* 24:104–114. <https://doi.org/10.1101/lm.044032.116>
- Corson Y, Verrier N, Bucic A (2009) False memories and individual variations: the role of field dependence–independence. *Pers Individ Differ* 47:8–11. <https://doi.org/10.1016/j.paid.2009.01.036>
- Davidson WB, House WJ (1978) Influence of reflection-impulsivity and cognitive style on time estimation under different ambient conditions. *Percept Mot Skills* 46:1083–1091. <https://doi.org/10.2466/pms.1978.46.3c.1083>
- Droit-Volet S (2013) Time perception in children: a neurodevelopmental approach. *Neuropsychologia* 51:220–234. <https://doi.org/10.1016/j.neuropsychologia.2012.09.023>
- Droit-Volet S, Monceau S, Berthon M, Trahanias P, Maniadakis M (2018) The explicit judgment of long durations of several minutes in everyday life: conscious retrospective memory judgment and the role of affects? *PLoS One* 13(4):e0195397. <https://doi.org/10.1371/journal.pone.0195397>
- Du Preez P (1967) Field dependence and accuracy of comparison of time intervals. *Percept Mot Skills* 24:467–472
- El Haj M, Moroni C, Samson S, Fasotti L, Allain P (2013) Prospective and retrospective time perception are related to mental time travel: evidence from Alzheimer's disease. *Brain Cognit* 83:45–51. <https://doi.org/10.1016/j.bandc.2013.06.008>
- Elkind D, Koegler RR, Go E (1963) Field independence and concept formation. *Percept Mot Skills* 17:383–386
- Goode PE, Goddard PH, Pascual-Leone J (2002) Event-related potentials index cognitive style differences during a serial-order recall task. *Int J Psychophysiol* 43:123–140
- Goodenough DR (1975) The role of individual differences in field dependence as a factor in learning and memory. *ETS Res Bull Ser 1*:i-54. <https://doi.org/10.1002/j.2333-8504.1975.tb01047.x>
- Grondin S, Laflamme V (2015) Stevens's law for time: a direct comparison of prospective and retrospective judgments. *Atten Percept Psychophys* 77:1044–1051. <https://doi.org/10.3758/s13414-015-0914-5>
- Grondin S, Plourde M (2007) Judging multi-minute intervals retrospectively. *Q J Exp Psychol* 60:1303–1312. <https://doi.org/10.1080/17470210600988976>
- Haldemann J, Stauffer C, Troche S, Rammsayer T (2011) Processing visual temporal information and its relationship to psychometric intelligence. *J Individ Differ* 32:181–188. <https://doi.org/10.1027/1614-0001/a000050>
- Hashimoto Y, Yotsumoto Y (2018) The amount of time dilation for visual flickers corresponds to the amount of neural entrainments measured by EEG. *Front Comput Neurosci* 12:30. <https://doi.org/10.3389/fncom.2018.00030>
- Hayashi MJ, Valli A, Carlson S (2013) Numerical quantity affects time estimation in the suprasecond range. *Neurosci Lett* 543:7–11. <https://doi.org/10.1016/j.neulet.2013.02.054>
- Herbst SK, Javadi AH, van der Meer E, Busch NA (2013) How long depends on how fast—perceived flicker dilates subjective duration. *PLoS One* 8(10):e76074. <https://doi.org/10.1371/journal.pone.0076074>
- Herbst SK, Chaumon M, Penney TB, Busch NA (2015) Flicker-induced time dilation does not modulate EEG correlates of temporal

- encoding. *Brain Topogr* 28:559–569. <https://doi.org/10.1007/s10548-014-0389-z>
- Jantzen TB, Thompson WF, Ammirante P, Ranvaud R (2014) Timing skills and expertise: discrete and continuous timed movements among musicians and athletes. *Front Psychol* 5:1482. <https://doi.org/10.3389/fpsyg.2014.01482>
- Johnston A, Arnold DH, Nishida S (2006) Spatially localized distortions of event time. *Curr Biol* 16:472–479. <https://doi.org/10.1016/j.cub.2006.01.032>
- Kanai R, Paffen CLE, Hogendoorn H, Verstraten FAJ (2006) Time dilation in dynamic visual display. *J Vis* 6:1421–1430
- Kaneko S, Murakami I (2009) Perceived duration of visual motion increases with speed. *J Vis* 9(7):14. <https://doi.org/10.1167/9.7.14>
- Lhamon WT, Goldstone S (1975) Movement and the judged duration of visual targets. *BPS* 5:53–54
- Linares D, Gorea A (2015) Temporal frequency of events rather than speed dilates perceived duration of moving objects. *Sci Rep* 5:8825. <https://doi.org/10.1038/srep08825>
- Matthews WJ, Meck WH (2016) Temporal cognition: connecting subjective time to perception, attention, and memory. *Psychol Bull* 142:865–907. <https://doi.org/10.1037/bul0000045>
- Michon JA (1972) Processing of temporal information and the cognitive theory of time experience. In: Fraser JT, Haber FC, Müller GH (eds) *The study of time*. Springer, Berlin, pp 242–258
- Mioni G, Stablum F, McClintock SM, Grondin S (2014) Different methods for reproducing time, different results. *Atten Percept Psychophys* 76:675–681. <https://doi.org/10.3758/s13414-014-0625-3>
- Okajima M, Yotsumoto Y (2016) Flickering task-irrelevant distractors induce dilation of target duration depending upon cortical distance. *Sci Rep* 6:32432. <https://doi.org/10.1038/srep32432>
- Phillips JR (1977) Relationship of field-dependence-independence to posture and judgment of time duration. *Percept Mot Skills* 44:931–940
- Plomp G, van Leeuwen C, Gepshtein S (2012) Perception of time in articulated visual events. *Front Psychol* 3:564. <https://doi.org/10.3389/fpsyg.2012.00564>
- Silverman AJ, Cohen SI, Shmavonian BM, Greenberg G (1961) Psychophysiological investigations in sensory deprivation. The body-field dimension. *Psychosom Med* 23:48–62. <https://doi.org/10.1097/00006842-196101000-00006>
- Spiro RJ, Tirre WC (1980) Individual differences in schema utilization during discourse processing. *J Educ Psychol* 72:204–208
- Tascón L, Boccia M, Piccardi L, Cimadevilla JM (2017) Differences in spatial memory recognition due to cognitive style. *Front Pharmacol* 23:8:550. <https://doi.org/10.3389/fphar.2017.00550>
- Tobin S, Bisson N, Grondin S (2010) An ecological approach to prospective and retrospective timing of long durations: a study involving gamers. *PLoS One* 5(2):e9271. <https://doi.org/10.1371/journal.pone.0009271>
- Turgeon M, Lustig C, Meck WH (2016) Cognitive aging and time perception: roles of bayesian optimization and degeneracy. *Front Aging Neurosci* 8:102. <https://doi.org/10.3389/fnagi.2016.00102>
- Wearden JH, Wearden AJ, Rabbit PMA (1997) Age and IQ effects on stimulus and response timing. *J Exp Psychol Hum Percept Perform* 23:962–979
- Witkin HA (1949) Perception of body position and of the position of the visual field. *Psychol Monogr* 63:i-46. <https://doi.org/10.1037/h0093613>
- Witkin HA (1977) Cognitive style in personal and cultural adaptation. Field-dependent and field-independent cognitive styles and their educational implications. Clark University Press, Worcester
- Witkin HA, Goodenough DR (1976a) Field dependence and interpersonal behavior. *ETS Res Bull Ser* 1:i-78. <https://doi.org/10.1002/j.2333-8504.1976.tb01098.x>
- Witkin HA, Goodenough DR (1976b) Field dependence revisited. *ETS Res Bull Ser* 2:i-85. <https://doi.org/10.1002/j.2333-8504.1976.tb01125.x>
- Witkin HA, Oltman PK, Raskin E, Karp S (1971) A manual for the embedded figures test. Consulting Psychologists Press, Palo Alto
- Wittmann M, Simmons AN, Flagan T, Lane SD, Wackermann J, Paulus MP (2011) Neural substrates of time perception and impulsivity. *Brain Res* 1406:43–58. <https://doi.org/10.1016/j.brainres.2011.06.048>
- Zakay D, Block RA (2004) Prospective and retrospective duration judgments: an executive-control perspective. *Acta Neurobiol Exp* 64:319–328
- Zakay D, Tsal Y, Moses M, Shahar I (1994) The role of segmentation in prospective and retrospective time estimation processes. *Mem Cognit* 22:344–351

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.