IJP&PT

International Journal of Psychology & Psyhological Therapy

International Journal of Psychology & Psychological Therapy is a four-monthly interdisciplinary publication open to publish original articles, reviews of one or more area(s), theoretical reviews, or methodological issues, and series of interest to some of the Psychology areas. The journal is published for the *Asociación de Análisis del Comportamiento* (AAC) and MICPSY, and indexed and/or abstracted in:

International Journal of Psychology & Psychological Therapy es una publicación interdisciplinar cuatrimestral, publicada por la Asociación de Análisis del Comportamiento (AAC), abierta a colaboraciones de carácter empírico y teórico, revisiones, artículos metodológicos y series temáticas de interés en cualquiera de los campos de la Psicología. Es publicada por la *Asociación de Análisis del Comportamiento* (AAC) y MICPSY y está incluida en las bases y plataformas bibliográficas:

- **Academic Search Complete** (*EBSCO Publishing Inc.*)
- **Cabell's Directory** (*Cabell Scholarly Analytics*)
- **CLARIVATE-WEB of SCIENCE** (*Emerging Sources Citation Index*)
- **ClinPSYC** (*American Psychological Association*)
- **DIALNET** (*Fundación Dialnet, Universidad de La Rioja*)
- **DICE-CSIC** (*Difusión y Calidad de las Revistas Españolas*)
- **Directory of Open Accest Journals** (DOAJ)
- **EBSCO Information Service**
- **GOOGLE Scholar Metrics**
- **IBECS** (*Índice Bibliográfico Español en Ciencias de la Salud*)
- **IN-RECS** (*Index of Impact of the Social Sciences Spanish Journals*)
- **ISOC** (CINDOC, CSIC)
- **Journal Scholar Metrics**
- **MIAR** (*Matriz de Información para el Análisis de Revistas*)
- **ProQuest Prisma Database**
- **Psychological Abstracts**(*American Psychological Association*)
- **PsycINFO** (*American Psychological Association*)
- **RÉBIUN** (*Red de Bibliotecas Universitarias Españolas*)
- **RESH** (*Revistas Españolas deCiencias Sociales y Humanidades*)
- **SCIMAGO** (*SCImago Journal & Country Rank -SCOPUS*)
- **SCOPUS** (*Scopus Database Elsevier*)

International Journal of Psychology & Psychological Therapy, 2022, 22, 3, 245-263

Time Perception and Emotion: A Systematic Review

Beatriz Harana Lahera

Universidad de Almería, España

Abstract

Since the beginning of experimental studies in psychology, there has been a keen interest in analyzing the factors that distort our perception of time as human beings. The manipulation of emotional or/and motivational states has been critical to understanding how an individual's perception of time changes. However, experimental studies to date have been highly diverse in their procedures and the instruments used to measure such perceptions. This paper proposes a systematic review of the topic in question. The main aim of this work is to describe and compare different experimental studies conducted with adults. After a rigorous selection of search terms introduced in each database, inclusion criteria were applied, while one article was added through citation search. A total of 17 articles with 26 experimental studies were analyzed. The results were discussed, and further research should be advanced.

Key words: time perception, passage of time, emotion, motivation, systematic review.

How to cite this paper: Harana-Lahera B (2022). Time Perception and Emotion: A Systematic Review. *International Journal of Psychology & Psychological Therapy, 22, 3,* 245-263.

Novelty and Significance

What is already known about the topic?

- A number of experimental studies have been conducted on the impact of emotions on time perception.
- Some literature reviews exist, but a systematic review has not been carried out to date.

What this paper adds?

- A systematic review of human experimental studies about the influence of emotion on time perception.
- Analysis of perceptual measurement procedures that do not use millisecond interval discrimination tasks.

The perception of time has been a subject of interest in psychology since the beginning of experimental psychology in the XIX century. For instance, Vierordt (1868) and his students were pioneers in conducting different experiments on the discrimination of short and long-time intervals. Their results indicated that an individual is more likely to perceive short intervals as longer while long intervals as shorter than they are (Lejeune & Wearden, 2009). These studies seem to be the first evidence of time perception. Later on, four methods to measure time perception were developed from Vierodt's studies (Wearden, 2016): Reproduction, Production, Comparison, and Verbal Estimation. In the Reproduction method, auditory or visual stimuli are presented in a specific interval, and the participant is asked to reproduce the previous interval. For example, an instructor taps twice on a table, and the participant taps the third time. The interval between the second and third tap should have the same duration as the interval between the first and second tap (Boltz, 1994; Bausenhart, Dyjas, & Ulrich, 2014; Jones & Wearden, 2003). In the Production method, participants are asked to carry out an action on a specific time. For example, the instructor tells the participant to press a key for 30 seconds (Fortin & Breton, 1995; Tamm, Uusberg, Allik, & Kreegipuu, 2014; Wearden & McShane, 1988). In the Comparison method, participants go on a training phase and then a test phase. In the training phase, the participant learns to discriminate between a short interval (400ms) and a long interval (1600ms). Subsequently, in the test phase, the participant has to classify different intervals as short (e.g., 600 ms) or long (1600 ms), among others (Allan & Gibbon, 1991; Brown, McCormack, Smith, &

* *Correspondence*: Beatriz Harana Lahera, Departamento de Psicología, Universidad de Almería, Carretera Sacramento s/n, 04120, La Cañada de San Urbano, Almería, España. E-mail address: bhl304@ual.es

Stewart, 2005; Church & Deluty, 1977; Kopec & Brody, 2010). Finally, in the Verbal Estimation method, participants must indicate how much time has elapsed in a given interval. For instance, after experiencing an interval of unknown duration, the participant stated that it was 20 minutes long (Bell, 1975; Boltz, 1993; Franssen & Vandierendonck, 2002). Each of the above four methods has used different types of intervals. Usually, tasks involving the comparison methods use intervals of milliseconds (Allan & Gibbon, 1991; Wearden, 1992). However, experiments involving the estimation method have used longer and more varied intervals, ranging from five minutes to an hour (Meade, 1963; Schönbach, 1959; Vohs & Schmeichel, 2003). Depending on the method used, the instructions given to the participant about the aim of the study were different. In the comparison method, for instance, the participant is aware that s/he asked about time perception. In contrast, when using an estimation method, the participant does not necessarily know the aim of what s/he is being asked until s/he is being asked about it. In this regard, Hicks, Miller, and Kinsbourne (1976) divided the measurement methods into two categories: Prospective, in which the participant is informed that the study aims to measure the perception of time; and Retrospective, where the participant is not informed about the aim of the study.

Beyond the key concepts related to the measurement of time perception already described, it is necessary to consider the conditions under which behavior occurs. More specifically, the context of the motivational and emotional responses involved when doing any particular activity and the present factors. In this regard, over the years, time perception has been measured using different types of tasks. For instance, studies where motivational and emotional factors were considered somehow (Angrilli, Cherubini, Pavese, & Manfredini, 1997; Droit-Volet, Brunot, & Niedenthal, 2004; Gil, Neidenthal, & Droit-Volet, 2007; Meade, 1959), or those related to attention responses (Böhmelt, Schell, & Dawson, 1999; Fortin & Rousseau, 1987; Im & Varma, 2018; Tamm et alia, 2014; Zhang, Liu, Wang, Chen, & Luo, 2014).

Most experimental studies on attention responses have not measured or even considered the emotional and motivational responses (Brown, 1985; Thomas & Weaver, 1975; Wearden & Towse, 1994). However, as in any other behavior, emotions play a relevant role in the behavior of time perception. In other words, the impact of different emotional responses while performing an attention task might result not only in different performance in such a task but also in different estimations of time and different sensations or judgements about how slowly or quickly time has passed. For example, Charlotte spends the entire morning working as a receptionist, doing tasks that she finds boring. At the end of the morning, she mentions to her colleagues that the morning went by very slowly. However, the next day, her boss tells her he is raising her salary and changing her assigned tasks for more fulfilling ones. At the end of the working day, Charlotte mentions that she has been doing good work and that she would have liked to have more time to spend on her new tasks, as the hours went by quickly. Accordingly, experimental studies addressing time perception should consider several factors that are part of any instance of behavior, such as the emotional and motivational states involved in doing any specific task, even when said task is simply guessing how much time has passed. A further complication is that experimental studies should follow the track of individual behavior instead of the average responses provided by different people. In this way, any given behavior is in the context of the individual history of that person. Therefore, all these significant challenges must be kept in mind when reviewing the studies carried out to date on the topic of relating emotion and time perception.

There is a large line of research regarding the interaction between emotion and time perception. Most of these research articles have used comparison methods and time intervals shorter than 2 seconds. This has been the case in the studies conducted during the last 20 years by Droit-Volet and her collaborators as perhaps one of the most frequent groups in analyzing time perception (e.g., Chambon, Gil, Niedenthal, & Droit-Volet, 2005; Cocenas-Silva, Bueno, & Droit-Volet, 2012; Droit-Volet, 2016; Droit-Volet, Brunot, & Niedenthal, 2004; Droit-Volet, Bigand, Ramos, & Bueno, 2010; Droit-Volet & Coull, 2015; Droit-Volet, Fayolle, & Gil, 2011, 2016; Droit-Volet & Gil, 2016; Droit-Volet, Lamotte, & Izaute, 2015; Droit-Volet, Mermillod, Cocenas-Silva & Gil, 2010; Effron, Niedenthal, Gil, & Droit-Volet, 2006; Fayolle, Droit-Volet, & Gil, 2014; Fayolle, Gil, & Droit-Volet, 2015; Gil, Niedenthal, & Droit-Volet, 2007; Gil & Droit-Volet, 2011, 2012; Gil, Rousset, & Droit-Volet, 2009; Grommet, Droit-Volet, Gil, Hemmes, Baker, & Brown, 2011; Mondillon, Niedenthal, Gil, & Droit-Volet, 2007). Other authors have followed the same system, as was the case with Baccarani, Grondin, Laflamme, & Brochard (2021); Gable & Poole (2012); Gagnon, Bégin, Laflamme, & Grondin (2018); Grommet, Hemmes, & Brown (2019); Kliegl, Watrin, & Huckauf (2015); Tipples (2008); Nicol, Tanner, & Clarke (2013); Tomas & Španić (2016); Van Elk & Rotteveel (2019); Weng, Wang, Zhang, Wang, & Luo (2021); Zhang, Zhang, Yu, Liu, & Luo (2017).

One might think that studies on time perception, even when researchers belong to the same group or collaborate, might give some common factors so that a general conclusion might be formulated. Nevertheless, it seems difficult to reach a general conclusion through all these studies because the differences among them (e.g., in the manipulation of emotional responding, the type of task used, or the way that time perception is measured) establish a differential context for each of them. For instance, the reviews by Wearden (2016) conclude that the impact of task manipulation was usually minimal, meaning that time perception hardly changes except when stimuli apparently devoted to inducing aversive emotions (such as sadness, pain, or anger) were implemented. High variability among procedures, measures, and, consequently, results were also detected. Other reviews have been oriented to detect the correlations between time perception and specific emotional states in clinical and non-clinical populations (Droit-Volet, Fayolle, Lamotte, & Gil, 2013; Gable, Wilhelm, & Poole, 2022). The same pattern of variability in procedures, measures, and results was detected in the previous reviews. However, no systematic review of the relation between emotional responses and time perception has been conducted. This article aims to fulfill this gap by describing and comparing the procedures and results of time perception papers with the following criteria: (a) studies in which the individual's motivation has been manipulated as well as has been measured; (b) studies that have used intervals longer than one minute, and (c) studies conducted with non-clinical population and without taking any drugs or medications during the experiment.

Method

Search Strategy and Criteria Selection

A systematic search was carried out using three databases: ISI Web of Knowledge (Web of Science), Psychology Database ProQuest, and Scopus, following the guidelines of the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA; Page *et alia*, 2021). The key terms were introduced using the operators AND, OR

and NOT as follows: “time perception” OR “passage of time” AND “motivation” OR “emotion” NOT (“animals”) NOT (“children” OR “adolescents”) NOT (“drugs” OR “substance abuse” OR “medications” OR “pharmacological agents”) NOT (“mental illness” OR “mental disorder” OR “disorder patient” OR “mental disability” OR “patients” OR “clinical”). These terms were introduced in English, and the filter title, abstract, and keywords fields were used (except in the case of Psychology Database ProQuest, in which the search was conducted in the abstract field). Furthermore, the sub-area of psychology was added to these search criteria.

Due to the large number of studies found, the following specific inclusion criteria were applied: (1) experimental studies with at least one manipulation of the participant’s emotional and motivational state; (2) measurement of time perception after the emotional state manipulation; (3) intervals of more than 1 minute; (4) no clinical adult population (over or equal to 18 years old); (5) participants were not under the influence of any drugs or medication during the experimental task.

Study Selection

Once the search terms were introduced into the databases, 680 papers were identified (see Figure 1). Then, the duplicates were removed, leaving 510 papers. A total of 14 out of 510 papers were excluded for these reasons: (a) the complexity of translating two articles from Japanese (2 out of 14 papers); (b) the entire article could not be found (12 out of 14 papers). Therefore, the inclusion criteria were applied to 496 papers, and the sample was reduced to 16. Additionally, one article identified by the citation search met the inclusion criteria and was added, making a total of 17 articles. These 17 papers resulted in 29 experimental studies, of which 26 studies met the inclusion criteria and constituted the final sample of this review.

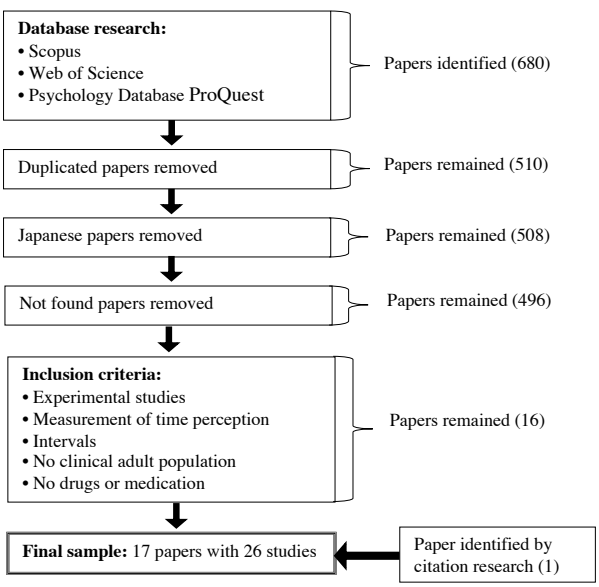

Figure 1. Diagram following PRISMA indications (Page *et alia*, 2021).

Results

A summary of 17 articles with 26 experimental studies is described below. All these experiments coincided in measuring time perception using estimation methods with or without judgements of the passage of time (the participant's sensation of time passing faster or slower). All the information analyzed is described in Table 1 as follows: Article columnn, which involves the citation of the articles (those articles containing more than one experimental study were specified with an ordinal number at the end), Prospective "P" and/or Retrospective "R" method, the number of participants "N," and a symbol "*" when participants were instructed not to have clocks available during the performance of the experimental task; Aim column, the purpose of the study; Design/ Manipulation column, inter-subject and/or intra-subject design, and how motivation and emotion were manipulated; Time Task column, the type of task used to measure time perception and intervals; Procedure column, the process that was followed in the experiment; and Results column, a summary of the findings according to experimental conditions.

The relevant results of Table 1 are summarized as follows. First, regarding the instruction given to the participants, 16 out of 26 studies explicitly stated that participants were instructed not to have contact with clocks during the experiment. Second, concerning the Prospective and/or Retrospective method, 18 out of 26 studies were Retrospective, 4 studies were Prospective, 2 studies used both, and 2 studies without specifying if a Prospective or Retrospective method was used; Third, in terms of the design, most studies (17 out of 26) used inter-subject designs, 5 studies used intra-subject, and 4 studies used both. Fourth, there was a high level of variability concerning emotional and motivational manipulations and the type of task used. Fifth, all studies used the time estimation method with or without time judgement, with different intervals (from less than two minutes to one hour). Sixth, 23 out of 26 studies specified in their procedure that participants were asked about their emotional and motivational state during or after the experimental task, and 17 out of those studies specified the exact or approximate number of participants who matched the expected emotional state for such manipulation. Seventh, the time perception results showed considerable variability since, as mentioned, the type of emotional manipulation changes greatly from one study to another, as well as the intervals.

Due to the great diversity of emotional and motivational manipulations, task types, and outcomes, a new classification of experimental conditions was carried out. This classification was done following two steps. First, those studies (17 out of 26) that specified how many participants met the expected emotional state for that experimental condition were selected. In other words, for how many participants the experimental manipulation worked. Second, a total of 23 out of 62 experimental conditions (from 17 studies) met the criteria to be classified in one of the following three emotional response categories: (+) those conditions in which participants rated their emotional state as pleasant, fun, or satisfied (during or after performing the task), or in which participants were making good progress during the experimental task; (-) conditions in which participants reported themselves as anxious, sad, frustrated or in pain (during or after performing the task), or in which participants did not make any progress during the experimental task or were private about something that they wanted to obtain; (θ) conditions described in (-) but in this case, it involves only those conditions in which Participants have been instructed to link the experimental task with a specific aim (e.g.,

Table 1. Summary of reviewed studies. For each article it is detailed the main objective (Aim); type of design and experimental manipulations (Design/Manipulation); a list of experimental conditions (Conditions); intervals and type of task used (Time Tasks); the main steps throughout the study (Procedure); main results reported (Results).

Article	Aim	Design/Manipulation	Conditions	Time Tasks	Procedure	Results
Schönbach (1959)* 1st, R, *N*= 100	Influence of the need to eat, to think about food, and the desire to eat on time perception.	Inter-subject / The need to eat through food deprivation according to: (HN) High Need: participants did not eat anything on the day of the experiment. (LN) Low Need: participants received instructions to eat normally on the day of the study. - Participants rated how much they liked the following: (R) Relevant: the sections of a cookbook. (I) Irrelevant: a folder with various fashion designs. (NS) No stimulation No task was assigned to participants.	• HN-R • HN-I • HN-NS • LN-R • LN-I	Two 13-minute tasks: Task 1: participants grade how much they like different images, depending on each condition. Task 2: participants performed a puzzle to obtain another measure of time estimation.	Step 1. A delay is announced due to preparations (waiting room). Step 2. After 13-minute, Participants answered: (a) estimate the length of delay period and indicating how slowly or rapidly time passed; (b) how much liked the rating task or no stimulation condition; (c) how much thought about food; (d) how strong desired to start; (e) how much hungry they were. Step 3. Appetizing arrangement of four cookies A, B, C, and D, ten piece of each type, and a drink, whatever Participant had chosen previously. Participants ate and drank as much as they wanted to. Step 4. Participants indicate how they liked A, B, C, and D cookies on rating scales. Step 5. Participants play with a pegboard puzzle alone for 13 min. Step 6. Participants estimate time spent doing puzzle: a) how slowly or rapidly time passed; b) how much liked working on puzzle.	- Food images (conditions R) increased the desire to taste from LN and HN conditions. Food images did not affect hunger in LN. - In all conditions, time was underestimated. Participants in R conditions gave an estimation closer to the real interval. - Time elapses more slowly in the HN-R condition than in the others. - No data on time estimation during puzzle task.
Schönbach (1959)* 2nd R, *N*= 34	Whether the change of activity varied time perception.	Inter-subject / Participants rated according to how much they liked the following: Relevant (R): the different sections of a fashion book with images of dresses and the latest fashion clothes. Irrelevant (I): the different sections of a cookbook with images of desserts, cakes, and other similar items.	• R • I	One 13-minute task: Participants scored how much they liked the different images.	Step 1. Participants received the information: the major fashion houses in Europe and America had decided to sponsor this study on the tastes and preferences of women in fashion. Step 2. A representative of the Parisian fashion world was introduced. Her task would be to examine dresses for as long as she wishes and fill in a short questionnaire to indicate her preferences. Step 3. Experimenter mentioned a delay due to some preparations. He asked Participants to rate fashion designs (R) or other recipes (I). Step 4. Participants had to indicate: (a) the length of the last period and to indicate it on a rating scale; (b) how much they liked the rating task; (c) how much they thought about fashion; (d) how strong was her desire to start examining dresses; (e) how many hours she would be able to spend on other fashion shows.	- Scoring of the recipes was less liked than the fashion designs. Difference between R and I conditions is significant since Participants looked forward to seeing fashionable clothes. - Rating of the recipes distracted them from thinking about the promised fashion show that awaited them. - Participants in condition I gave lower time estimates than those in R.
Meade (1963)* R, *N*= 160	Impact of pain during task performance on time perception.	Inter-subject - The importance of the task: High Motivation (HM) Participants instructed that maze's outcome reflected their intelligence. Low Motivation (LM) maze's outcome was unimportant. - Rate of progress: Slow (S) Participants received scores indicated they had advanced one/no region per trial. Fast (F) Scores indicated that they advanced one or more regions.	16 conditions with different intervals: • HM-F • HM-S • LM-F • LM-S	Two tasks with 4 different intervals (15, 30, 45, and 60 m): Task 1: Participants complete achievement test. Task 2: Participants make a maze.	Step 1. Participants was required to do an achievement test (the duration to complete it was the same interval as the maze). Step 2. Each participant received instructions according to their experimental condition. All participants had 12 trials, each followed by a rest-pause. Step 3. During rest period, Experimenter gave Participant his score for that trial. Step 4. At the end of 12 trials, Participants had to answer the questions: (a) on which one did they think they were working the longer; (b) How long they were doing the maze (time estimation); (c) Feelings about the maze.	- Participants in HM-F provided higher underestimation than in LM-S, in intervals 15 and 30m. - In LM-S, most of Participants overestimated in all intervals. - No results show how slowly or quickly Participants passed the time.

Notes: *= The study details instructions for ensuring that participants do not have clocks available during experimental tasks; m= minutes; *N*= number of participants; P= prospective instructions; R= retrospective instructions; s= seconds.

Table 1 (continuation). Summary of reviewed studies. For each article it is detailed the main objective (Aim); type of design and experimental manipulations (Design/Manipulation); a list of experimental conditions (Conditions); intervals and type of task used (Time tasks); the main steps throughout the study (Procedure); main results reported (Results).

Article	Aim	Design/Manipulation	Conditions	Time Tasks	Procedure	Results
Meade (1966a)* R, *N*= 80	Relation between progress, needs, and time perception.	Inter-subject - Achievement test to select Participants High Needs (HN): High score. Low Needs (LN): Low score. - The same as Meade (1963)	• HN-F • HN-S • LN-F • LN-S	Similar to Meade (1963) with two 15m tasks.	Similar to Meade (1963).	- The F condition had a shorter time estimate than the S group. - Having HN or LN correlates significantly with feelings of progress and estimation results.
Meade (1966b) R, *N*= 60	Impact of negative progress on time perception.	Inter-subject Rate of progress: Forward (F): Participants had to advance one or two regions toward the goal after each trial. Zero (Z): Participants had to move either one region forward or backward or not to move. Backward (B): Participants had to move one or two regions further away from the goal after each trial.	12 conditions with different intervals: • F • Z • B	Similar to Meade (1963).	Similar to Meade (1963) adapted the instructions for step 2 according to these new conditions.	For all time intervals, Participants showed longer estimates when neither moving forward nor backward (zero progress) and shorter estimates in F and B conditions.
Meade & Singh (1970)* R, *N*= 280	Effects of motivation and progress on time perception through different cultures.	Intra-subject Similar to Meade (1963).	• HM-F • HM-S • LM-F • LM-S	Two 6-minute tasks: Task 1: Looking at a magazine. Task 2: Cancelling the letter "o" from a page of jumbled letters.	Similar to Meade (1963) with different tasks, no precise information is given on the questions asked after the tasks.	In HM-F, most participants underestimated. Whereas when LM-S, most of Participants overestimated.
Cohen (1971)* R, *N*= 60	Influence of achievement oriented task on time perception.	Inter-subject Importance of tasks Filled (F): Participants were informed about the importance of task before starting a puzzle, Unfilled (U): Waiting period.	• F • U	Two tasks: 6 trials of 3 intervals (30-75- 120s) Task 1: A blindfolded maze-tracing activity on an unsolvable puzzle. Task 2: Periods of blindfolded rest.	Step 1. Experimenter explained to the participant the maze and that this maze was highly correlated with intelligence and success. Step 2. Participants had to estimate passages of time after blindfolded maze-tracing activity on an unsolvable puzzle. Step 3. Participant had a blindfolded rest. Step 4. Participant had to estimate passages of time during the rest.	Participants overestimated time in all periods and both tasks. The most considerable discrepancies arose in the U task.
Troutwine & O'Neal (1981) NI, *N*= 40	Effects of a tedious and interesting task on time perception.	Inter-subject - Interest of the task: Interesting (I): Tape with an absorbing vignette from classical mythology. Boring (B): Tedious passage from a text on ethics - With or without choice: With (W): Participants decided whether to listen to the tape a second time. Without (WO): Tape was presented for the 2nd time.	• I-W • I-WO • B-W • B-WO	A task (no information about interval): Participants listen to a tape and estimate duration.	Step 1. Participants first listened to a brief audiotape of learning material and answered questions about it. Step 2. Participants instructed to turn the tape recorder off and take a break in the listening after thought a 5-min session had elapsed. Step 3. After break, according to each choice condition, the tape was presented or not for the 2nd time. Step 4. Finally, Participants rated the tapes and were fully informed about the purpose of the study.	- For Participants of B-W and B-WO groups, time passed longer than Participants of I group. - There are no differences between W or WO conditions. - No information is given on exact time estimation results.

Notes: *= The study details instructions for ensuring that participants do not have clocks available during experimental tasks; m= minutes; *N*= number of participants; NI= No information about prospective or retrospective instructions; P= prospective instructions; R= retrospective instructions; s= seconds.

Table 1 (continuation). Summary of reviewed studies. For each article it is detailed the main objective (Aim); type of design and experimental manipulations (Design/Manipulation); a list of experimental conditions (Conditions); intervals and type of task used (Time Tasks); the main steps throughout the study (Procedure); main results reported (Results).

Article	Aim	Design/Manipulation	Conditions	Time Tasks	Procedure	Results
Thorn & Hansell (1993)* R, *N*= 80	Influence of pain on time perception.	Inter-subject - Importance of the task: Specific (S): Participants endure the pain for 3m. Nonspecific (N): Participants endure the pain as long as possible. - Pain level: Pain (P). (WP) Without pain.	• S-P • N-P • S-WF • N-WP	Task with 2 intervals (120s and at time of withdrawal): Participants put their non-dominant hand on a cold-water pressor.	Step 1. Experimenter instructed Participants to complete the task according to each condition. Step 2. Participants had to answer: (a) questions about pain ratings 30s and 120s after immersion; (b) questions about time estimations of how long thought they had their hands in the water at 120s and at the time of withdrawal.	Most of the Participants underestimated in N-P; Most of the Participants overestimated in N-WP. No difference between S-P and S-WP conditions. In both, most of the Participants adjust to real-time.
Vohs & Schmeichel (2003)* 1st, R; *N*= 39	Whether the feeling of the passage depends on different emotional video clips.	Inter-subject Emotional expression: Suppress (S): The participants had to remain completely neutral on the inside and out. Exaggerate (E): The participants had to express their feeling as much as possible. Natural (N): The participants were required to act as naturally as possible.	• S • E • N	11m 23s Task: watching a clip of a thatch shows a dying mother saying goodbye to her family.	Step 1. Experimenter said Participants that they would watch a short clip, and read the instructions depending on each condition. and told them that they would be recording while watched the clip. Step 2. Participants watched the clip. Step 3. Participants completed questions: (a) a mood scale; (b) how long the clip was (estimation); (c) level of confidence judgments of duration estimate; (d) post-experimental questionnaire.	Participants who had exaggerated or suppressed their emotions perceived the film clip as longer than those who acted naturally.
Vohs & Schmeichel (2003)* 2nd, R; *N*= 54	Similar to Vohs & Schmeichel (2003) 1st study, but different conditions.	Inter-subject The same as Vohs & Schmeichel (2003) 1st study, except for: Reappraisal (R): Participants watch the film clip with the detached interest of a medical professional. They had to think about it objectively.	• S • R • N	10m 13s Task: watching a film clip about pollution.	Similar as Vohs & Schmeichel (2003) 1st study, except for Step 1. The participants for condition R received other instructions.	Taking perspective on emotion does not result in the same pattern of time getting longer, which it did when participants were asked to control their emotions.
Vohs & Schmeichel (2003)* 3rd, R, *N*= 48	Influence of emotional reaction on time perception.	Inter-subject Will of expressiveness Control (C): The participants had to act happy and smile while reading. No control (NC): The participants do not receive the below instruction.	• C • NC	A 4m 23s Task: reading aloud a book about psychologists.	Step 1. Experimenter informed task: reading aloud a book until he returned. Step 2. Participants read the book aloud. Step 3. Participants answered about time perception estimation. Step 4. Participants could continue the task for "as long as they could"; They could stop at that point (4m23s) or for up to 15 m. Step 5. Participants answered: (a) a mood scale; (b) how well they did the reading aloud task.	Participants in condition C perceived their task much longer than Participants in condition NC.
Vohs & Schmeichel (2003)* 4th, R, *N*= 45	Effect of conducting a resource exhaustion task on time perception."	Inter-subject/Intra subject - Instructions about thinking (inter subject): Think (T): Participants were not instructed to think about something. Do not think (NT): Participants instructed not to think of a white bear and instructions to place a checkmark on the thought-listing sheet if they have a bear thought. - Breath-holding samples (intra-subject): 1st breath (1B): pre-manipulation. 2nd breath (2B): post-manipulation.	• T-1B • T-2B • NT-1B • NT-2B	Task (no information about the interval): holding their breath.	Step 1. Participants received instruction to hold breath for as long as they are able or until they must give up. Step 2. Participants instructed to write whatever they were thinking explained that whatever they write will be anonymous. Instructions ended at this point for half of Participants, the rest received instructions for condition NT. Step 3. Participants had 6m for the thought-listing task. After, complete a mood scale. Step 4. Participants perform condition 2B, could stop when they could not continue or did not want to. Step 5. Participants completed: (a) how long they hold their breath in 2B; (b) post-experimental questionnaire.	This study replicated the results of Vohs & Schmeichel (2003) 1st and Vohs & Schmeichel (2003) 2nd. Participants with thought suppression estimated they held their breath longer than Participants who had not suppressed their thoughts.

Notes: *= The study details instructions for ensuring that participants do not have clocks available during experimental tasks; m= minutes; ms= miliseconds; *N*= number of participants; P= prospective instructions; R= retrospective instructions; s= seconds.

Table 1 (continuation). Summary of reviewed studies. For each article it is detailed the main objective (Aim); type of design and experimental manipulations (Design/Manipulation); a list of experimental conditions (Conditions); intervals and type of task used (Time Tasks); the main steps throughout the study (Procedure); main results reported (Results).

Article	Aim	Design/Manipulation	Conditions	Time Tasks	Procedure	Results
O'Brien *et alia* (2011)* 1st, R, *N*= 50	Relation between time perception and entitlement as a personality trait.	Inter-subject - Level of entitlement (scale conducted one month before the experiment): Higher (H): Participants with a high score. Lower (L): Participants with a low score. - Type of task: Boring (B): Participants reproduce the matrix task. Funny (F): Participants used the letters from matrix task to form people's first names.	• H-B • H-F • L-B • L-F	A 10-minute task: A matrix of uppercase and lowercase letters (depending on conditions B or F, Participants have different aims).	Step 1. Participants completed a scale about psychological entitlement one month before experiment. Step 2. On the day of the experiment, Experimenter explained the task to Participants according to their conditions. Step 3. Participants answer: (a) how many minutes they were doing the task; (b) interest of the task; (c) mood rate; (d) indication on a scale if they had enough time to do the task; (e) how much they are busy in their life; (f) a scale of sensation seeking.	- In condition H-B Participants perceived task as longer relative to L-B; no differences between trait entitlement and fun tasks. - Participants indicated a better mood in conditions F than in conditions B; no specific information about how time passed in conditions F. - No specific estimation data between the two tasks.
O'Brien *et alia* (2011)* 2nd, R, *N*= 65	Influence of entailment on time perception for boring tasks.	Inter-subject Instructions: Entitled (E): The aim was to learn more about opinions and personal preferences, Participants was entitled to the best possible experiences. Control (C): The aim was to understand opinions.	• E • C	Task (no information about the interval): Survey about favorite food or frequency with which eat fast food.	Step 1. Participants received instructions for entitled or control conditions. Step 2. Participants filled in the survey. Step 3. Last questions of the survey: (a) indicate on a scale if think that doing this survey was a waste of time; (b) estimate in minutes how long the survey was;(c) to indicate what set of instructions had received: entitled, control or bogus unused.	Participants in condition C perceived the survey as a greater waste of time and estimated it as longer than participants from condition E.
O'Brien *et alia* (2011)* 3rd, R, *N*= 60	Effects of subliminal superiority words on time perception.	Inter-subject Entitlement: Entitled (E): 80% of Entitlement and self-focused words: unique, superior, important (…) Control (C): Any entitlement and self-focused words: water, long, number (…).	• E • C	Three 4m tasks: Task 1: Participants press spacebar every time they saw a flash. Task 2: The same as in task 1, but only when the flash is blue. Task 3: Participants count flashes.	Step 1. Participants were told that different colored flashes (with subliminal words) would appear on computer screen. Step 2. Participants were told that the three tasks could take approximately 10 to 25min. Step 3. The tasks began. The words were displayed at 100ms. Step 4. Participants rated: (a) how fast the time passed (very slowly or very quickly); (b) interest of tasks.	Participants provided with words entitled to 80% felt the time passed more slowly than those with words no entitled.
Brand *et alia* (2016)* R, *N*= 90	Influence of different odors and tasks on time perception.	Inter-subject/Intra-subject - Different odors (inter-subject): Pleasant (P): 9ml of phenyl ethyl alcohol Unpleasant (U): 1.5 ml of pyridine Control (C): No odor. -Type of task (intra-subject): 1. Arranging cards: Participants order different landscape cards from lowest to highest. (2. Drawing: Participants draw small circles very quickly. 3. Math operations: Participants do different math operations.	• P • U • C	Tasks with different intervals: Task 1 (no time limit). Task 2 (137s). Task 3 (202s).	Step 1. Different odors sprayed into the room 20 minutes before (odors remained stable for 1 hour). Step 2. Researcher informed Participants that there might be odors in the experimental room previously used by other researchers for smelling studies. Step 3. Instructions were given to Participant for each task. After each task, Participants rate the task (0-10): (a) difficulty; (b) pleasantness; (c) time estimation; (d) stressful level; (e) concentration. Step 4. Once Participants completed the tasks, a scale was given to indicate (0-10) intensity, hedonic valence, and irritation.	- For most Participants in condition P, odor was pleasant, and unpleasant the odor in condition U. - Overestimation in all conditions during tasks 1 and 3. Participants underestimated in all conditions during task 2.

Notes: *= The study details instructions for ensuring that participants do not have clocks available during experimental tasks; m= minutes; ms= miliseconds; *N*= number of participants; P= prospective instructions; R= retrospective instructions; s= seconds.

Table 1 (continuation). Summary of reviewed studies. For each article it is detailed the main objective (Aim); type of design and experimental manipulations (Design/Manipulation); a list of experimental conditions (Conditions); intervals and type of task used (Time Tasks); the main steps throughout the study (Procedure); main results reported (Results).

Article	Aim	Design/Manipulation	Conditions	Time Tasks	Procedure	Results
Gable *et alia* (2016) 1st, R, *N*= 73	Impact of sadness on time perception.	Intra-subject Emotional state: Sad (S): Participants watch a film about two children describing the death of a younger sibling. Neutral (N): A film showed parts of a house.	• S • N	Two 1m 34s tasks: Watching film S or N.	Step 1. Participants watched a film (depending on each condition). Step 2. Participants answered: (a) how time passed during the film (7-point scale; from 1= time dragged to 7= time flew); (b) two scales about emotional state (from 1= positive to 9= negative), and motivational direction (from 1= move toward to 9= move away).	- Participants scored film in condition S more harmful than in N. - Nearer rating motivation during condition S than in N. - Participants rated time flew more during condition S.
Grondin *et alia* (2018) R, *N*= 72	If estimation changes depending on the memory type and the memories' longevity.	Inter-subject - Emotional memory recall: Joy (J): Memory of fun. Sadness (S): Sad memory. - Time passed since that memory. Old (O): Memory from 7-10 years old. Recent (R): Memory from two years.	• J-O • J-R • S-O • S-R	A 15m Task: Participants recall and write memory (S or J).	Step 1. Participants completed a mood survey (1st time). Step 2. Researcher instructed Participants to complete the memory recall task and informed the written material would be destroyed. Step 3. Participants completed: (a) the mood survey (2nd time); (b) a questionnaire of verbal estimation questions. Step 4. Participants completed: (a) mood survey (3rd time); (b) questionnaire attitudes towards time (past–negative, past–positive, present–fatalism, present–hedonism, and future).	- Condition J memories more pleasant than S. - Pleasant/unpleasant effect greater when memories belonged to condition R. - Participants tend to adjust or underestimate some seconds in conditions S. Overestimated in Condition J-R, and underestimated in J-O.
Droit-Volet *et alia* (2020) 1st, P, *N*= 87	Effect of emotion on time perception using different intervals.	Intra-subject - Different durations (with 3 targets and 2 additional ones): (A) 2-6s: Target durations 2, 4, and 6s. (B) 10-120s: Target durations 20, 40, and 60s. (C) 2-6m: Target durations 2, 4, and 6 m. - Sounds (*Audacity Software*): High (H) Moderate (M) Low (L)	• A-H • A-M • A-L • B-H • B-M • B-L • C-H • C-M • C-L	Task with different intervals: Listening to different sounds on the computer.	Step 1. Participants were told not to attempt to estimate duration by counting because it would bias the outcome of the study. Step 2. Participants performed 45 trials, divided into 3 blocks of 15 trials each. Step 3. After each trial Participants completed: (a) time estimation; (b) arousal and emotional valence 9-point scale.	- Much more overestimation in Conditions C than in the A and B. -Participants in C-H almost equaled the real-time. Underestimated in conditions of more than 1m (C-L and C-M). - Participants perceived stimuli as more negative in condition H than in M and L.
Droit-Volet *et alia* (2020) 2nd, P, *N*= 32	The same as 1st study, but using high and low sounds and one interval.	Intra-subject - Sounds: High (H) Low (L)	• H • L	The same task as Droit-Volet *et alia* (2020) st with intervals between 2-6m (target durations 2, 4, and 6m).	Procedure as in Droit-Volet *et alia* (2020) 2nd study except for Step 2: Two sounds and one interval (2-6 min).	- Estimation was longer in Condition H than in L. - Participants more aroused felt due to emotional stimuli, the more they overestimated durations.
Droit-Volet *et alia* (2020) 3rd, P, *N*= 18	Same as 1st study using the high and low sounds and one interval.	Intra-subject Films (3D virtual reality videos): High (H) Low (L)	• H • L	A 3D virtual reality task with the same intervals as 2nd study.	Procedure as in Droit-Volet *et alia* (2020) 2nd study except for the emotional stimuli and experimental arrangements for 3D virtual reality	Results where similar to the other two experiments, with a greater overestimation of duration of H compared to L in the range of minutes.

Notes: *= The study details instructions for ensuring that participants do not have clocks available during experimental tasks; m= minutes; ms= miliseconds; *N*= number of participants; P= prospective instructions; R= retrospective instructions; s= seconds.

Table 1 (continuation). Summary of reviewed studies. For each article it is detailed the main objective (Aim); type of design and experimental manipulations (Design/Manipulation); a list of experimental conditions (Conditions); intervals and type of task used (Time Tasks); the main steps throughout the study (Procedure); main results reported (Results).

Article	Aim	Design/Manipulation	Conditions	Time Tasks	Procedure	Results
Bagley *et alia* (2021) P, *N*= 34	If the induction of high stress could influence time perception.	Inter-subject Stress levels: Stress (S): Participant immersed his hand in water (0-4°C) for a maximum of 180s (they could remove it if were intolerable). Control (C): same as S, water between 24-27ºC.	• S • C	42s or 72s tasks: Participants were told they had to estimate an interval. No information about stimuli used.	Step 1. Participants completed: (a) demographic data, (b) mood questionnaire, (c) saliva sample, (d) estimation interval (47s-72s). Step 2. Participants performed a measure of cortisol (before and after) for the *Social Evaluative Cold Pressor Stressor Task* (Condition S) and Condition C, the *Warm Water Control Task*. Step 3. Participants completed: (a) mood questionnaire; (b) time estimation (applying the time interval used in step 1). Step 4. After 10m: (a) mood questionnaire; (b) saliva sample.	- Participants in Condition S provided a more inaccurate estimation than those in C. In Condition S Participants overestimated in the post, in C under-estimated coming closer to real-time. - Cortisol levels at baseline and after the water task, significantly different only for Condition S.
Kawabata & Chatzisarantis (2022) 1st, P & R, *N*= 102	Relation between time perception and affective aspects using computerized task.	Inter-subject - Information of estimation: Prospective (P): Participants estimate time before starting. Retrospective (R): Participants estimate at the end of task. - Type of task: Enjoyable (E): Moving a ball to a target in a maze. Position of target changed in each session. Boring (B): Moving a ball from the left side to a target on the right side. When the ball reached the target, a new session restarted with same target position. Neutral (N): The same as condition B, target location and ball start point altered.	• P-E • P-B • P-N • R-E • R-B • R-N	A 6-minute task: Participants asked to move a ball across a computer screen according to each condition.	Step 1. Participants received instructions to do the computerized task (depending on each condition) Step 2. After the task, Participants were asked: (a) to estimate duration of the task; (b) to assess -on a 10-point scale- their perception of speed of time, enjoyment and difficulty during the task; (c) to fill out an intrinsic motivation survey.	- Participants working on the E task perceived the task as more fun and requiring than N and B tasks. - In conditions E time passed significantly faster than in B or N - The effect of time estimation and the interaction between the type of task and prospective/ retrospective were not significant. - No data about the exact time estimation for each condition.
Kawabata & Chatzisarantis (2022) 2nd, P & R, *N*= 56	To compare the results of the 1st study with other tasks.	Inter-subject/Intra-subject - Information of estimation: (same as 1st study). - Order of tasks (intra-subject): Reading (D): Participants read an article about Einstein at their own pace. Computerize (C): Computer-validated task.	• P-D • P-C • R-D • R-C	Two 6-minute tasks: Task 1: Reading task. Task 2: Computerized task.	Similar procedure used as the 1st study, except for type of task and one questionnaire (achievement goal survey).	- In conditions D the enjoyment was higher than in C; stress level in D conditions was lower than in C. - Perceived time speed in the condition D was faster than in C. - Effect of time estimation and P/R were not significant. - No data about the exact estimation.
Martinelli & Droit-Volet (2022)* 2nd, NI, *N*= 82	Effect of emotion on perception of time at different intervals.	Intra-subject/Inter-subject -Different durations (inter-subject): Seconds (S): Stimuli duration 30, 33, and 36s. Minutes (M): Stimuli duration 90, 99, and 108s. - Type of stimuli (intra-subject): Positive (P): Video people having fun or animals. Neutral (T): Inanimate objects and facial expressions. Negative (N): Images featured garbage dumps, war, and people with sad expressions.	• S-P • S-T • S-N • M-P • M-T • M-N	Task with different intervals: Watching other stimuli through a computer.	Step 1. Participants performed two demonstration trials. Step 2. Participants performed 18 trials, 6 for each of the 3 emotional stimuli -negative, neutral, positive. For each trial, Participants were presented with the following: a) A fixed mark displayed for 500 ms in the center of the screen; b) A stimulus displayed at different durations. Step 3. After each trial, Participants answer questions about rating the passage of time (7-points scale, from 1= very slowly to 7= very fast).	- The passage of time was slower in the condition M than in S for stimuli N and P. - No differences in condition N between the two durations.

Notes: *= The study details instructions for ensuring that participants do not have clocks available during experimental tasks; m= minutes; ms= miliseconds; *N*= number of participants; NI= No information about prospective or retrospective instructions; P= prospective instructions; R= retrospective instructions; s= seconds.

to endure pain for 3 minutes or watch a video about someone's death from a medical perspective). Among these 23 conditions, 5 were categorized as (+), 16 conditions as (-), and 2 conditions as (θ).

Table 2 shows the results described above as follows: the articles; the number of participants; experimental conditions that met the criteria for one of the three categories of emotional response (and the exact or approximate number of participants for each one); and classification of the experimental conditions into one of the three categories [(+), (-), (θ)] and the exact or approximate number of participants who met the criteria.

The classifications of the experimental conditions in Table 2 were used to compare the results more straightforwardly in Table 3, which shows the following data: the articles; the time intervals used; the emotional response categories; the time estimations (emotional response categories in which most of the participants' estimations were over, under or equal to real time); and the time judgements (emotional response categories in which most of the participants felt the passage of time as slower or faster).

Data about the main time estimation and judgement results concerning its emotional response category and the interval used are indicated. First, regarding the time

Table 2. Some of the experimental conditions mentioned in table 1 categorized according to Participants' emotional responses (during/after the experimental task), indicating number of Participants.

Articles	*N*	Conditions**	Emotional Responses (+)	(-)	(θ)
Schönbach (1959) 1st	100	HN-R (*n*= 20)		18	
Troutwine & O'Neal (1981)	40	I-W (*n*= 10)	Most of 10		
		B-WO (*n*= 10)		Most of 10	
Thorn & Hansell (1993)	80	S-P (*n*= 20)			15
		N-P (*n*= 20)		14	
Vohs & Schmeichel (2003) 1st	39	S (*n*= 13)		Most of 13	
Vohs & Schmeichel (2003) 2nd	50	S (*n*= 17) *		Most of 17	
		R (*n*= 17) *			Most of 17
Vohs & Schmeichel (2003) 3rd	48	C (*n*= 24)		Most of 24	
Vohs & Schmeichel (2003) 4th	45	NT-2B (*n*= 23) *		Most of 23	
O'Brien *et alia* (2011) 1st	50	H-F (*n*= 15)	Most of 15		
		H-B (*n*= 15)		Most of 15	
O'Brien *et alia* (2011) 2nd	62	E (*n*= 27)		Most of 27	
Gable *et alia* (2016) 1st	73	S (*n*= 36) *		Most of 28	
Grondin *et alia* (2018)	61	J-R (*n*= 17)	17		
		S-R (*n*= 15)		15	
Droit-Volet *et alia* (2020) 1st	87	C-H (*n*= 87)		Most of 87	
Droit-Volet *et alia* (2020) 2nd	32	H (*n*= 32)		Most of 32	
Droit-Volet *et alia* (2020) 3rd	18	H (*n*=18)		9	
Bagley *et alia* (2021)	34	S (*n*= 16)		Most of 16	
Kawabata & Chatzisarantis (2022) 1st	102	R-E (*n*= 34)	Most of 34		
		R-B (*n*= 34)		Most of 34	
Kawabata & Chatzisarantis (2022) 2nd	56	R-D (*n*= 28)	Most of 28		
Total	977		104	382	32

Notes: *= indicate that number of participants is approximated in that condition (study does not specify the exact number); **= consult Conditions in Table 1; (+)= pleasant, satisfaction, or making progress; (-)= sadness, frustration, pain, not making progress or state of deprivation; (θ)= the same as (-) with the linking of a specific aim; *N*= total number of Participants/study; *n*= number of Participants in the specific condition.

Table 3. This table shows each article mentioned in table 2 with its general result (time estimation and judgement), according to the type of emotional response and interval used.

Articles	Intervals	Emotional responses	Estimation			Judgement	
			Over	Under	Equal	Slower	Faster
Grondin *et alia* (2018)	≥15	+ (*n*= 17)	X				
O'Brien *et alia* (2011) 1st	≥15	+ (*n*≅ 15)		X			
Kawabata & Chatzisarantis (2022) 1st	≥6	+ (*n*≅ 34)					X
Kawabata & Chatzisarantis (2022) 2nd	≥6	+ (*n*≅ 28)					X
Troutwine & O'Neal (1981)	NI	+ (*n*≅ 10)					X
Vohs & Schmeichel (2003) 2nd	≥15	- (*n*≅ 17)	X				
O'Brien *et alia* (2011) 1st	≥15	- (*n*≅ 15)	X				
Vohs & Schmeichel (2003) 3rd	≥6	- (*n*≅ 24)	X				
Bagley *et alia* (2021)	≥2	- (*n*≅ 16)	X				
Vohs & Schmeichel (2003) 4th	NI	- (*n*≅ 23)	X				
O'Brien *et alia* (2011) 2nd	NI	- (*n*≅ 27)	X				
Schönbach (1959) 1st	≥15	- (*n*= 18)		X		X	
Vohs & Schmeichel (2003) 1st	≥15	- (*n*≅ 13)		X			
Droit-Volet *et alia* (2020) 1st	≥6	- (*n*≅ 87)		X			
Droit-Volet *et alia* (2020) 2nd	≥6	- (*n*≅ 32)		X			
Droit-Volet *et alia* (2020) 3rd	≥6	- (*n*= 9)		X			
Thorn & Hansell (1993)	≥2	- (*n*= 14)		X			
Grondin *et alia* (2018)	≥15	- (*n*= 15)			X		
Kawabata & Chatzisarantis (2022) 1st	≥6	- (*n*≅ 34)				X	
Troutwine & O'Neal (1981)	NI	- (*n*≅ 10)				X	
Gable *et alia* (2016) 1st	≥2	- (*n*≅ 28)					X
Thorn & Hansell (1993)	≥2	θ (*n*= 15)			X		
Vosh & Schmeichel (2003) 2nd	≥15	θ (*n*≅ 17)			X		

Notes: NI= No information is given on the time interval used in the experimental procedure; *n*= number of Participants emotional response.

intervals: 4 out of 23 emotional response categories (from 3 studies) do not indicate which intervals were used; 8 out of 23 categories used intervals of less or equal to 15 minutes; 7 out of 23 categories used intervals of less or equal to 6 minutes; 4 out of 23 categories used intervals of less or equal to 2 minutes. Second, concerning the categories that measured time estimation and/or judgement: 17 out of 23 emotional response categories measured time estimation, and 7 out of 23 measured time judgement. Third, time estimation results are described according to the emotional response categories: in the (+) emotional response (5 out of 23), the majority of participants overestimated the time in 1 out of 5 (+) categories, and most participants underestimated time in 1 out of 5 (+) categories. No time estimation data were found in the results of the other 3 (+) categories. In the (-) emotional response (16 out of 23), the greater part of the participants underestimated the time in 6 out of 16 (-) categories, most participants overestimated the time in the other 6 out of 16 (-) categories, and most participants from 1 out of 16 (-) categories got very close to estimating the real time. There are 3 out of 16 (-) categories that did not show data about time estimation. In the (θ) categories (2 out of 23), most participants adjusted to the real time. Forth, time judgement results are detailed depending on the emotional response categories: Regarding the (+) emotional response (5 out of 23), in 3 out of 5 (+) categories, time judgement data were shown,

and for most of their participants, time passed faster; As for (-) emotional response (16 out of 23), 4 out of 16 (-) categories showed data on time judgement. In 3 out of these 4 (-) categories, for most participants the passage of time was slower, and in 1 out of 4 (-) categories, for most participants time passed faster. No time judgement results were observed in the (θ) category.

DISCUSSION

The analysis of the 23 experimental studies has been challenging, with considerable variability in the procedure and outcomes. The main findings of the analysis are presented as follows: (1) the studies have used different intervals (from less than two minutes to one hour); (2) the experimental tasks used to generate particular emotion and motivation responses vary enormously from one study to another (e.g., watching a video or pictures, doing a puzzle or mathematical operations, listening to sounds, among others); (3) Not all studies have tested whether the experimental manipulation really generate the expected emotional and motivational responses in the participants (e.g., to present a videoclip and then ask the participant how they felt while they were watching the clip); (4) Some of the studies that test the participant's mood during or after the experimental task do not provide sufficient data about the number of participants who felt that particular emotion or motivation; (5) The majority of the studies provide measures of time estimation but do not measure how slow or fast time passed for the participants; (6) The results on time estimation shows a great deal of variability (e.g., it is not clear whether, when an individual is having a bad time, the individual' estimation was over, under or equal to real time), despite the classification of the studies according to three emotional response categories; (7) A pattern on the results of the judgment of the passage of time can be observed in some of the studies classified into emotional response categories (e.g., those experimental conditions in which participants informed that they had fun or felt pleasant, time went faster versus those experimental conditions in which participants reported that they felt bored or unpleasant); (8) There are scarce studies that generate a pain or discomfort task and associate it with a specific aim (e.g., keeping the hand in cold water for 3 minutes or watching a movie about someone's death from a medical perspective); (9) The data from all the studies are nomothetic (with inter-subject designs in most of them), there is not an individual analysis of the one participant's emotional or motivational state and their specific perception of time. Each of these conclusions will be discussed in the following paragraphs.

Concerning the wide variety of intervals used in the different studies, it is not clear whether the time is perceived differently depending on whether the interval is shorter (2-5 minutes) or longer (40-45 minutes) (Bagley *et alia*, 2021; Meade, 1963, 1966; Troutwine & O'Neal, 1981). Perhaps, more replication of experimental studies in this area would be needed to see if the results show any specific pattern (e.g., studies in which the experimental context is manipulated to generate amusement in one participant during a 2-minute interval and on another occasion, the experimental context is manipulated to generate the same emotion in that particular participant during a 15-minute interval). Furthermore, as mentioned above, there is no line or direction to follow to manipulate emotional and motivational states. Each of these studies used different tasks to manipulate the experimental context. Probably, there is a lack of replication studies under the same motivational and emotional manipulations.

Another aspect to discuss is the assessment of the emotional and motivational states during or after the experimental task. Some studies do not specify whether such assessments were made or whether they assumed that the participant felt a particular emotion. Conducting experiments without verifying and specifying the participant's emotional state during or after the experimental task does not conclude anything about the interaction of a particular emotional response and time perception. In addition, most studies that measured participants' emotional and motivational states do not accurately report the exact number of participants who felt one way or another. Therefore, it is difficult to determine and conclude, as a whole from all these studies, how the perception of time oscillates according to emotions.

Regarding the type of time perception measurement, in many of the studies analyzed, the emphasis is on time estimation data without measuring the sensation or judgement of the passage of time (e.g., time is passing slower or faster) (Grondin *et alia*, 2018; O'Brien, Anastasio, & Bushman, 2011; Vohs & Schmeichel, 2003). Perhaps one could wonder whether overestimating or underestimating may be related to time slowing down or speeding up under the same experimental conditions. For example, in one of the studies (Schönbach, 1959), it was observed that in an experimental condition where participants were deprived of food, most participants underestimated the time, but the task passed slower for them. In other words, according to this study, one's feelings about how slowly time passed are not necessarily correlated with an overestimation. Possibly more replicates of studies are needed to corroborate this effect.

Another point mentioned is that the studies have a multitude of experimental conditions that are intended to generate motivational states. For example, most studies manipulate context to generate specific motivational states, such as fun, pleasure, boredom, pain, and sadness, but what would happen when, in a situation of discomfort, an individual performs an action that links to a specific aim? The data showed a very low number of participants under this last experimental condition. In particular, two studies created these types of conditions (Thorn & Hansell, 1993; Vohs & Schmeichel, 2003): in one study, the participants placed their hands in cold water with the aim of keeping the hand for 3 minutes; in the other study the participants had to watch a video clip about the death of a person with the aim of watching it from a medical perspective. The perception of time seems to have been different for these participants compared to those who simply went through an unpleasant or painful situation. Further replication of this latter event is needed to reach more precise conclusions on changes in emotional response and temporal perception. Also, one might assess how time perception changes when an individual undergoes a painful or uncomfortable task and links each task step to something meaningful for them. Consider the following example: David is very afraid of speaking in public. Whenever he has to give a presentation at the University, he has a hard time. Every minute takes so long. One day, David had to give a speech at a conference. He wanted to dedicate this speech to his grandmother. During the presentation, David had his grandmother in his mind every moment. That day, the speech did not pass slowly. As a result, David's time perception changed. This example above reflects an event that may be worth studying.

In summary, the data do not show systematicity between the procedures and the estimation results. Therefore, a detailed analysis of the same conditions leading to the same results should be carried out. Regarding the sensations or judgements of the passage of time results, a pattern has been observed among some of the studies. This pattern suggests that when participants informed that they were having fun or in a pleasant state,

time passed more quickly than when they were having a bad time or in an unpleasant situation. Even so, the data from the studies are general and nomothetic, and it is not possible to observe the data of the emotional states of each participant accurately.

Apart from the proposed studies and replicates mentioned above, further studies could conduct a participant-by-participant analysis of each experimental condition with ideographic data. Nomothetic analysis has advantages, but it does not consider each participant's individual history. Each person has tastes or preferences that are not necessarily the same for everyone. Also, one person may tend to rate their emotional state as low (either bad or good), and another person may tend to rate their emotional state as high. In this way, the effect of the emotional and motivational manipulations on time perception would be more clearly observed if one studies the emotion and the fluctuation of time perception through the same participant, according to their individual history (e.g., a math task may be more enjoyable for those people who have been good at math throughout their lives and are skilled at it). Perhaps, through more ideographic experimental studies, it would be possible to have a much more global vision in this area, leading to a scientific underpinning for new lines of research.

REFERENCES

Angrilli A, Cherubini P, Pavese A, & Manfredini S (1997). The influence of affective factors on time perception. *Perception and Psychophysics, 59*, 972-982. Doi: 10.3758/bf03205512

Allan L & Gibbon J (1991). Human bisection at the geometric mean. *Learning and Motivation, 22,* 39-58. Doi: 10.1016/0023-9690(91)90016-2

Baccarani A, Grondin S, Laflamme V, & Brochard R (2021). Relaxing and stimulating effects of odors on time perception and their modulation by expectancy. *Attention, Perception, & Psychophysics*, *83*, 448-462. Doi: 10.3758/s13414-020-02182-0

Bagley S L, Massner K, Schneider C, Miller A, & Moore K (2021). That moment felt like forever: Stress affects on time perception in males. *Timing & Time Perception*, *9*, 285-300. Doi: 10.1163/22134468-bja10025

Bausenhart KM, Dyjas O, & Ulrich R (2014). Temporal reproductions are influenced by an internal reference: Explaining the Vierordt effect. *Acta Psychologica, 147*, 60-67. Doi: 10.1016/j.actpsy.2013.06.011

Bell CR (1975). Effects of lowered temperature on time estimation. *Quarterly Journal of Experimental Psychology, 27*, 531-538. Doi: 10.1080/14640747508400515

Böhmelt AH, Schell AM, & Dawson ME (1999). Attentional modulation of short- and long-lead-interval modification of the acoustic startle eyeblink response: Comparing auditory and visual prestimuli. *International Journal of Psychophysiology, 32*, 239-250. Doi: 10.1016/s0167-8760(99)00019-7

Boltz MG (1994). Changes in internal tempo and effects on the learning and remembering of event durations. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*, 1154-1171. Doi: 10.1037/0278-7393.20.5.1154

Boltz MG (1993). Time estimation and expectancies. *Memory and Cognition, 21*, 853-863. Doi: 10.3758/BF03202753

Brand G, Thiabaud F, & Dray N (2016). Influence of ambient odors on time perception in a retrospective paradigm. *Perceptual and Motor Skills*, *122*, 799-811. Doi: 10.1177/0031512516647716

Brown SW (1985). Time perception and attention: The effects of prospective versus retrospective paradigms and task demands on perceived duration. *Perception and Psychophysics, 38*, 115-124. Doi: 10.3758/bf03198848

Brown GDA, McCormack T, Smith M, & Stewart N (2005). Identification and bisection of temporal durations and tone frequencies: Common models for temporal and non-temporal stimuli. *Journal of Experimental Psychology: Human Perception and Performance, 31*, 919-938. Doi: 10.1037/0096-1523.31.5.919

Chambon M, Gil S, Niedenthal PM, & Droit-Volet S (2005). Psychologie sociale et perception du temps: l'estimation temporelle des stimuli sociaux et émotionnels. *Psychologie Française*, *50*, 167-180. Doi: 10.1016/j.psfr.2004.10.008

Church RM & Deluty MZ (1977). Bisection of temporal intervals. *Journal of Experimental Psychology: Animal Behavior Processes, 3*, 216-228. Doi: 10.1037/0097-7403.3.3.216

Cocenas-Silva R, Bueno JLO, & Droit-Volet S (2012). Temporal memory of the emotional experience. *Memory & Cognition*, *40*, 161-167. Doi: 10.3758/s13421-011-0145-5

Cohen DB (1971). Dream recall and short-term memory. *Perceptual and Motor Skills*, *33*, 867-871. Doi: 10.2466/pms.1971.33.1.101

Droit-Volet S (2016). Time does not fly but slows down in old age. *Time & Society*, *28*, 60-82. Doi: 10.1177/0961463X16656852

Droit-Volet S, Bigand E, Ramos D, & Bueno JLO (2010). Time flies with music whatever its modality. *Acta Psychologica*, *135*, 226-236. Doi: 10.1016/j.actpsy.2010.07.003

Droit-Volet S, Brunot S, & Niedenthal P (2004). Perception of the duration of emotional events. *Cognition and Emotion*, *18*, 849-858. Doi: 10.1080/02699930341000194

Droit-Volet S & Coull J (2015). The developmental emergence of the mental time-line: Spatial and numerical distortion of time judgement. *PloS one*, *10*, e0130465. Doi: 10.1371/journal.pone.0130465

Droit-Volet S, El-Azhari A, Haddar S, Drago R, & Gil S (2020). Similar time distortions under the effect of emotion for durations of several minutes and a few seconds. *Acta Psychologica*, *210*, 103170. Doi: 10.1016/j.actpsy.2020.103170

Droit-Volet S, Fayolle SL, & Gil S (2011). Emotion and time perception: effects of film-induced mood. *Frontiers in integrative neuroscience*, *5*, 33. Doi: 10.3389/fnint.2011.00033

Droit-Volet S, Fayolle SL, & Gil S (2016). Emotion and time perception in children and adults: The effect of task difficulty. *Timing & Time Perception*, *4*, 7-29. Doi: 10.1163/22134468-03002055

Droit-Volet S, Fayolle S, Lamotte M, & Gil S (2013). Time, emotion, and the embodiment of timing. *Timing Time Percept, 1*, 99-126. Doi: 10.1163/22134468-00002004

Droit-Volet S & Gil S (2016). The emotional body and time perception. *Cognition and Emotion*, *30*, 687-699. Doi: 10.1080/02699931.2015.1023180

Droit-Volet S, Lamotte M, & Izaute M (2015). The conscious awareness of time distortions regulates the effect of emotion on the perception of time. *Consciousness and Cognition*, *38*, 155-164. Doi: 10.1016/j.concog.2015.02.021

Droit-Volet S, Mermillod M, Cocenas-Silva R, & Gil S (2010). The effect of expectancy of a threatening event on time perception in human adults. *Emotion*, *10*, 908-914. Doi: 10.1037/a0020258

Effron DA, Niedenthal PM, Gil S, & Droit-Volet S (2006). Embodied temporal perception of emotion. *Emotion*, *6*, 1. Doi: 10.1037/1528-3542.6.1.1

Fayolle S, Droit-Volet S, & Gil S (2014). Emotion and time perception: Effects of film-induced mood. *Procedia-Social and Behavioral Sciences*, *126*, 251-252. Doi: 10.1016/J.SBSPRO.2014.02.399

Fayolle S, Gil S, & Droit-Volet S (2015). Fear and time: Fear speeds up the internal clock. *Behavioural processes*, *120*, 135-140. Doi: 10.1016/j.beproc.2015.09.014

Fortin C & Breton R (1995). Temporal interval production and processing in working memory. *Perception & Psychophysics*, *57*, 203-215. Doi: 10.3758/BF03206507

Fortin C & Rousseau R (1987). Time estimation as an index of processing demand in memory search. *Perception and Psychophysics, 42*, 377-382. Doi: 10.3758/bf03203095

Franssen V & Vandierendonck A (2002). Time estimation: does the reference memory mediate the effects of knowledge of results? *Acta Psychologica, 109*, 239-267. Doi: 10.1016/s0001-6918(01)00059-2

Gable PA, Neal LB, & Poole BD (2016). Sadness speeds and disgust drags: Influence of motivational direction on time perception in negative affect. *Motivation Science*, *2*, 238-255. Doi: 10.1037/mot0000044

Gable PA & Poole BD (2012). Time flies when you're having approach-motivated fun: Effects of motivational intensity on time perception. *Psychological Science*, *23*, 879-886. Doi: 10.1177/0956797611435817

Gable P, Wilhelm A, & Poole B (2022). How does emotion influence time perception? A review of evidence linking emotional motivation and time processing. *Frontiers in Psychology*, *13*, 848154. Doi: 10.3389/fpsyg.2022.848154

Gagnon C, Bégin C, Laflamme V, & Grondin S (2018). Temporal processing of joyful and disgusting food pictures by women with an eating disorder. *Frontiers in Human Neuroscience*, *12*, 129. Doi: 10.3389/fnhum.2018.00129

Gil S & Droit-Volet S (2011). "Time flies in the presence of angry faces"… depending on the temporal task used! *Acta Psychologica*, *136*, 354-362. Doi: 10.1016/j.actpsy.2010.12.010

Gil S & Droit-Volet S (2012). Emotional time distortions: The fundamental role of arousal. *Cognition & Emotion*, *26*, 847-862. Doi: 10.1080/02699931.2011.625401

Gil S, Niedenthal PM, & Droit-Volet S (2007). Anger and time perception in children. *Emotion, 7*, 219-225. Doi: 10.1037/1528-3542.7.1.219

Gil S, Rousset S, & Droit-Volet S (2009). How liked and disliked foods affect time perception. *Emotion*, *9*, 457-463. Doi: 10.1037/a0015751

Grommet EK, Droit-Volet S, Gil S, Hemmes NS, Baker AH, & Brown BL (2011). Time estimation of fear cues in human observers. *Behavioural Processes*, *86*, 88-93. Doi: 10.1016/j.beproc.2010.10.003

Grommet EK, Hemmes NS, & Brown BL (2019). The role of clock and memory processes in the timing of fear cues by humans in the temporal bisection task. *Behavioural Processes*, *164*, 217-229. Doi: 10.1016/j.beproc.2019.05.016

Grondin S, Laflamme V, Mioni G, Morin A, Désautels F, & Bisson N (2018). Retrospective temporal judgment of the period dedicated to recalling a recent or an old emotional memory. *Timing & Time Perception*, *6*, 169-182. Doi: 10.1163/22134468-20181128

Hicks RE, Miller GW, & Kinsbourne M (1976). Prospective and retrospective judgments of time as a function of amount of information processed. *The American Journal of Psychology*, *89*, 719-730. Doi: 10.2307/1421469

Im SH & Varma S (2018). Distorted time perception during flow as revealed by attention-demanding cognitive task. *Creativity Research Journal*, *30*, 295-304. Doi: 10.1080/10400419.2018.1488346

Jones LA & Wearden JH (2003). More is not necessarily better: Examining the nature of the temporal reference memory component in timing. *Quarterly Journal of Experimental Psychology, 56B*, 321-343. Doi: 10.1080/02724990244000287

Kawabata M & Chatzisarantis NL (2022). Does time fly when you engage more? Effort intensity moderates the relationship between affect and time perception. *Current Psychology*, *41*, 1-10. Doi: 10.1007/s12144-022-03191-y

Kliegl KM, Watrin L, & Huckauf A (2015). Duration perception of emotional stimuli: Using evaluative conditioning to avoid sensory confounds. *Cognition and Emotion*, *29*, 1350-1367. Doi: 10.1080/02699931.2014.978841

Kopec CD & Brody CD (2010). Human performance on the temporal bisection task. *Brain and Cognition, 74*, 262-272. Doi: 10.1016/j.bandc.2010.08.006

Lejeune H & Wearden JH (2009). Vierordt's "The experimental study of the time sense" (1868) and its legacy. *European Journal of Cognitive Psychology, 21*, 941-960. Doi: 10.1080/09541440802453006

Martinelli N & Droit-Volet S (2022). What factors underlie our experience of the passage of time? Theoretical consequences. *Psychological Research*, *86*, 522-530. Doi: 10.1007/s00426-021-01486-6

Meade R (1959). Time estimates as affected by motivational level, goal distance, and rate of progress. *Journal of Experimental Psychology, 58*, 275-279. Doi: 10.1037/h0049035

Meade RD (1963). Effect of motivation and progress on the estimation of longer time intervals. *Journal of Experimental Psychology: General*, *65,* 564-567. Doi: 10.1037/h0046552

Meade RD (1966a). Achievement motivation, achievement, and psychological time. *Journal of Personality and Social Psychology*, *4*, 577-580. Doi: 10.1037/h0023900

Meade RD (1966b). Progress direction and psychological time. *Perceptual and Motor Skills*, *23*, 115-118. Doi: 10.2466/pms.1966.23.1.115

Meade RD & Singh L (1970). Motivation and progress effects on psychological time in subcultures of India. *The Journal of Social Psychology*, *80*, 3-10. Doi: 10.1080/00224545.1970.9712512

Mondillon L, Niedenthal PM, Gil S, & Droit-Volet S (2007). Imitation of in-group versus out-group members' facial expressions of anger: A test with a time perception task. *Social Neuroscience*, *2*, 223-237. Doi: 10.1080/17470910701376894

Nicol JR, Tanner J, & Clarke K (2013). Perceived duration of emotional events: evidence for a positivity effect in older adults. *Experimental Aging Research*, *39*, 565-578. Doi: 10.1080/0361073X.2013.839307

O'Brien EH, Anastasio PA, & Bushman BJ (2011). Time crawls when you're not having fun: Feeling entitled makes dull tasks drag on. *Personality and Social Psychology Bulletin*, *37*, 1287-1296. Doi: 10.1177/0146167211408922

Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R, Glanville J, Grimshaw JM, Hróbjartsson A, Lalu MM, Li T, Loder EW, Mayo-Wilson E, McDonald S, McGuinness LA, Stewart LA, Thomas J, Tricco AC, Welch VA, Whiting P, & Moher D (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Systematic reviews*, *10*, 1-11. Doi: 10.1136/bmj.n71

Schönbach P (1959). Cognition, motivation, and time perception. *The Journal of Abnormal and Social Psychology*,

58, 195. Doi: 10.1037/h0040457

Tamm M, Uusberg A, Allik J, & Kreegipuu K (2014). Emotional modulation of attention affects time perception: Evidence from event-related potentials. *Acta Psychologica, 149*, 148-156. Doi: 10.1016/j.actpsy.2014.02.008

Thomas EA & Weaver WB (1975). Cognitive processing and time perception. *Perception & psychophysics*, *17*, 363-367.

Thorn BE & Hansell PL (1993). Goals for coping with pain mitigate time distortion. *The American Journal of Psychology*, *106*, 211-225. Doi: 10.2307/1423168

Tipples J (2008). Negative emotionality influences the effects of emotion on time perception. *Emotion, 8,* 127-131. Doi: 10.1037/1528-3542.8.1.127

Tomas J & Španić AM (2016). Angry and beautiful: The interactive effect of facial expression and attractiveness on time perception. *Psihologijske Teme*, *25*, 299-315.

Troutwine R & O'Neal EC (1981). Volition, performance of a boring task, and time estimation. *Perceptual and Motor Skills*, *52*, 865-866. Doi: 10.2466/pms.1981.52.3.865

Van Elk M & Rotteveel M (2020). Experimentally induced awe does not affect implicit and explicit time perception. *Attention, Perception, & Psychophysics*, *82*, 926-937. Doi: 10.3758/s13414-019-01924-z

Vierordt K (1868). *Der Zeitsinn nach Versuchen*. Tübingen: Laupp.

Vohs KD & Schmeichel BJ (2003). Self-regulation and extended now: Controlling the self-alters the subjective experience of time. *Journal of Personality and Social Psychology*, *85*, 217-230. Doi: 10.1037/0022-3514.85.2.217

Wearden JH (1992). Temporal generalization in humans. *Journal of Experimental Psychology: Animal Behavior Processes, 18*, 134-144. Doi: 10.1016/0376-6357(94)90046-9

Wearden J (2016) *The Psychology of Time Perception*. London: Palgrave Macmillan.

Wearden JH & McShane B (1988). Interval production as an analogue of the peak procedure: Evidence for similarity of human and animal timing processes. *Quarterly Journal of Experimental Psychology*, *40B*, 363-375.

Wearden JH & Towse JN (1994). Temporal generalizations in humans: Three further studies. *Behavioural Processes*, *32*, 247-263. Doi: 10.1016/0376-6357(94)90046-9

Weng CC, Wang N, Zhang YH, Wang JY, & Luo F (2021). The Effect of Electrical Stimulation-Induced Pain on Time Perception and Relationships to Pain-Related Emotional and Cognitive Factors: A Temporal Bisection Task and Questionnaire-Based Study. *Frontiers in Psychology*, *12*, 800774-800774. Doi: 10.3389/fpsyg.2021.800774

Zhang D, Liu Y, Wang X, Chen Y, & Luo Y (2014). The duration of disgusted and fearful faces is judged longer and shorter than that of neutral faces: The attention-related time distortions as revealed by behavioral and electrophysiological measurements. *Frontiers in Behavioural Neurosciences, 8*, 293. Doi:10.3389/fnbeh.2014.00293.

Zhang M, Zhang L, Yu Y, Liu T, & Luo W (2017). Women overestimate temporal duration: Evidence from Chinese emotional words. *Frontiers in Psychology*, *8*, 4. Doi: 10.3389/fpsyg.2017.00004

Received, August 30, 2021
Final Acceptance, September 22, 2022