The Synchrony/Asynchrony Effect on Eyewitness Memory Performance

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The synchrony/asynchrony effect on eyewitness memory performance

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Abstract

This study aimed to investigate the synchrony/asynhrony effect on eyewitness memory. Forty-four participants (24 evening-types and 20 morning-types) performed, individually, two online sessions: one in the morning and another in the evening. In each session, each participant visualized two videos (crime and neutral scenes), answered questions related to the videos and completed additional questionnaires. In general, the participants' memory was better in the synchrony when compared to the asynchrony moment. In the crime videos, participants recalled more central details and in the neutral videos more peripherical details. The pattern of results remains similar when controlled by stress, anxiety, and depression.

Keywords: synchrony/asynchrony; time-of-day; memory; eyewitness testimony; chronotype.

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Introduction

People differ in their preferred time-of-day for sleep and activity, as determined by their chronotype, being divided into three main categories: morning-, evening- and neither-type. Morning-types (MT) prefer waking up early in the morning and have difficulties to stay awake beyond their usual bedtime. MT start their day with a high level of alertness, however, throughout the day, they experience a decrease in activation level (Adan et al., 2012; Horne & Ostberg, 1976). Evening-types (ET) prefer later sleep times and experience difficulties to get up early in the morning. Further, they reach their peak of physical and mental activity later during the day (Adan et al., 2012; Horne & Ostberg, 1976; Roenneberg, 2012). Neither-types (NT) show no strong morning or evening preference since they have greater schedule flexibility (Horne & Ostberg, 1976; Roenneberg, 2012). About 60% of the adult population are classified as NT, while the remaining 40% are classified as morning- or evening-types (Adan et al., 2012).

The "synchrony effect" suggests an alignment or synchrony between time-of-day and chronotype, which could potentially result in better cognitive performance and productivity. Based on this hypothesis, it is expected that MT have a better cognitive performance in the morning and ET at end of day (Krishnan & Lyons, 2015; May, 1999). Previous research into the synchrony effect has focused on several cognitive domains, such as attention and vigilance (Matchock & Toby Mordkoff, 2009), inhibitory control (Song et al., 2018) and memory tasks (Hidalgo et al., 2004). For example, Hidalgo et al. (2004) investigated memory performance of different chronotypes during morning and evening shifts. Results revealed the MT had higher scores on the metamemory tests and the evening-types showed higher scores in the afternoon.

Different types of memory are affected differently by chronotype (Hidalgo et al., 2004; Yaremenko et al., 2021a). In the case of long-term memory, specifically episodic

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memory, the performance follows the mentioned pattern of synchrony effect (Yaremenko et al., 2021b). This is justified by the fact that the capacity for attention is associated with variations on the circadian peaks, making the encoding and retrieval of memorized information more effective when synchronized with the circadian peak (Roenneberg, 2012). In contrast, asynchrony of the task with our internal rhythms could cause low performance, such as low memory performance (Schmidt et al., 2007).

In eyewitness testimony, memory is a crucial cognitive process and highly associated with the veracity of the testimony. Witnesses represent an important source of information in court, especially when there is no other type of evidence (e.g., physical evidence) and, therefore, testimony may be crucial for the judge's decision-making (Odinot & Wolters, 2006). To collect information as accurately as possible, it is important to use appropriate techniques. One of the techniques mostly used in criminal investigation is free recall, in which the eyewitness is instructed to freely describe all the details remembered about the event (Lindsay et al., 2007). Memory for high negative emotional load events (e.g., crimes) have some particularities. Depending on the intensity of its activation and how individuals experience that event, memory can be positively or negatively affected by emotional state, such as stress, anxiety, and depression (e.g., Gray, 2001; Moran, 2016). Several authors suggest that emotionally charged events simplify the process of memorizing information, making the witnesses remember more easily central details, related to the characteristics of the perpetrators and the victims, in opposition to neutral events, where the witnesses usually direct the attention to the peripheral details, that is, to what goes on around the event (Christianson & Loftus, 1987; Yegiyan & Lang, 2010). However, some studies indicate that stress experienced in an event may negatively influence memory, since attentional capacity is very limited to a

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particular element of the crime scene (e.g., weapon focus; (Kramer et al., 1990), and memory errors can occur (Bajos & Migueles, 1999).

Despite the existence of several studies that explore the relationship between time-of-day, chronotype and performance in several cognitive tasks, there is a paucity of studies in this relationship in the field of Forensic/Testimony Psychology. An exception is the study of Yaremenko et al. (2021b), who revealed that eyewitness identification was not affected by time-of-day. However, a lack of empirical evidence is observed about the effect of time-of-day on memory as measured by free recall tasks.

Bases on a free recall task, this work aimed to verify if there were significant differences in eyewitness testimony for central and peripheral details between synchrony and asynchrony sessions both in crime and neutral videos.

Methods

Study design

Following an experimental within-subject design, each participant, individually, completed two online experimental sessions at different times of day: one in the morning (between 7 a.m. and 10:30 a.m.) and another at the end of the day (between 6 p.m. and 10 p.m.), with an interval of one week. The order of the videos and sessions (synchrony vs. asynchrony) were counterbalanced across participants to avoid learning and order effects, as well as to mitigate potential individual differences.

Participants

The initial sample was composed of one hundred and thirty-eight participants which completed the Portuguese version of the Morningness-Eveningness Questionnaire (MEQ) (Silva et al., 2002). The MEQ scores allowed to classify participants into

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chronotypes (MT, NT, ET), to select the final sample (n = 48). Four participants was excluded, since they did not complete the two experimental sessions. The final sample included 44 participants, 20 morning-types (≥54 points in the MEQ) and 24 evening-types (≤42 points in the MEQ), aged between 18 and 40 years (M = 23.80; SD = 5.73), 34 females and 10 males, who voluntarily participated in experimental sessions. NT (n = 90) were not included in experimental sessions given that they have greater schedule flexibility (Horne & Ostberg, 1976; Roenneberg, 2012). Chronotype (as measured by the MEQ) were used as criterion to define synchrony and asynchrony sessions. See Table 1 for sociodemographic characteristics for the total sample.

Table 1. Sociodemographic characteristics for total sample

	Total (N = 44)
Sex	
Female [n (%)]	34 (77.30)
Male [n (%)]	10 (22.70)
Age	
Min-Max	18-40
Mean	23.80
Standard Deviation	5.73
Stress	
Min-Max	0-14
Mean	6.02
Standard Deviation	4.22
Anxiety	
Min-Max	0-11
Mean	2.64
Standard Deviation	3.10
Depression	
Min-Max	0-20
Mean	3.64
Standard Deviation	4.03

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Materials

Videos

Two emotional videos (crime scenes) and non-emotional videos (neutral scenes) were applied in the experiment, since we intended to compare the participants' memory performance under situations with different emotional charge. The videos were sourced from an open database (free of copyrights) and were used solely for research purposes, and their inclusion in this study falls under fair use exemptions for scientific purposes[1].

Stress numerical rating scale

To assess participants' subjective stress levels, a numerical rating scale were applied, ranging from 0 (*not stressed at all*) to 6 (*extremely stressed*). The stress level was measured at the beginning of each experimental session to be considered as control variable and it was also measured at the end of the session to ensure that no participant was in distress at the end of each session (Alho et al., 2019).

Distracting task

It has been created for preventing that the participants' performance was based on working memory and preventing rehearsal (e.g., repetition of information) between viewing the video and recalling the memory (Morgan et al., 2019). For this purpose, four versions of a popular sayings quiz were created, with a completion time of approximately 5 minutes/version (Morgan et al., 2019).

[1] The videos used in this work as well the database will be provided upon request to the corresponding author.

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Free recall task

After each video, a free recall task was administered. A matrix of all central and peripherical details of the videos was created by two independent researchers and, posteriorly, compared, being the final version constituted by converging points of both versions. The matrix aimed to analyse the quantity and precision of the details recalled by participants (Alho et al., 2019).

Depression, Anxiety and Stress Scale-21

The Portuguese version of the Depression, Anxiety and Stress Scale, with 21 items (Ribeiro et al., 2004) was administered. This is a self-report questionnaire with a distribution of an equal number of items for each dimension, in which the participant indicates on a four-point Likert scale the frequency of each symptom in the last week. The results of each subscale are defined by the sum of each item (7 items x 3 dimensions), which means that higher scores are equivalent to higher levels of negative affectivity. Its Portuguese version revealed good psychometric properties, specifically Cronbach's alphas of 0.85 for depression, 0.74 for anxiety, and 0.81 for stress.

Procedure

Based on the procedures used by Alho et al. (2019), a pilot study was conducted to select crime videos to experimental session. Twelve independent raters, 9 women and 3 men, aged between 18 and 26 years (M = 19.17, SD = 2.34), rated all videos in 7-point Likert scales in terms of vividness, arousal, and pleasantness, ranging from 1 (*nothing*) to 7 (*very much*). For each dimension (vividness, arousal, and pleasantness), there were no

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differences among the two crime videos and the two neutral (p_s > .05), but significant differences between crime and neutral videos (p_s < .013).

A second pilot study was conducted to test the functionality of the procedure with five independent participants. None revealed any problem with the procedure.

Following a within-subject design, in the experimental sessions, each participant (n = 44) performed, individually, two online experimental sessions (via Zoom), at different times of the day, with an interval of one week: one in the morning (between 7 a.m. and 10:30 a.m.), therefore, at the optimal time-of-day for MTs and non-optimal for ETs; and another session at the end of the day (between 6 p.m. and 10 p.m.), corresponding to the optimal time-of-day for ETs and non-optimal for MTs (Schmidt et al., 2007). The protocol for the two sessions was identical but the order of the videos applied in each session (crime vs. neutral) and the moment of the session (synchrony vs. asynchrony) were counterbalanced across participants to avoid learning and order effects. In the two sessions, the same person of the researcher team was present to provide instructions in the same way.

Participants started each experimental session by filling out the stress numerical rating scale, following by the visualization of the first video (crime or neutral); they were instructed to watch the video carefully and pay close attention. A five-minute retention interval was followed where participants were asked to complete the distracting task. Then, participants performed a free recall task, providing a free narrative of all visual details. Specifically, they were asked to report all details they remembered, including the sequence of actions and events and description of appearance of the people involved. Participants were also asked to make their report as complete and accurate as possible and had unlimited time to provide the free narratives (Lindsay et al., 2007).

After that, the second video was shown (if the crime video was viewed first, the neutral video was shown second, or vice-versa) and the remaining tasks were applied in

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the same order. At the end of the experimental session, participants were asked to complete the stress numerical rating scale to ensure that none of the participants was in distress.

The second session (one week after the first session) followed the same procedure, differing in the time-of-day. Also, at the end of the second session, the participants were asked to complete the Depression, Anxiety and Stress Scale-21 (Ribeiro et al., 2004). See Figure 1.

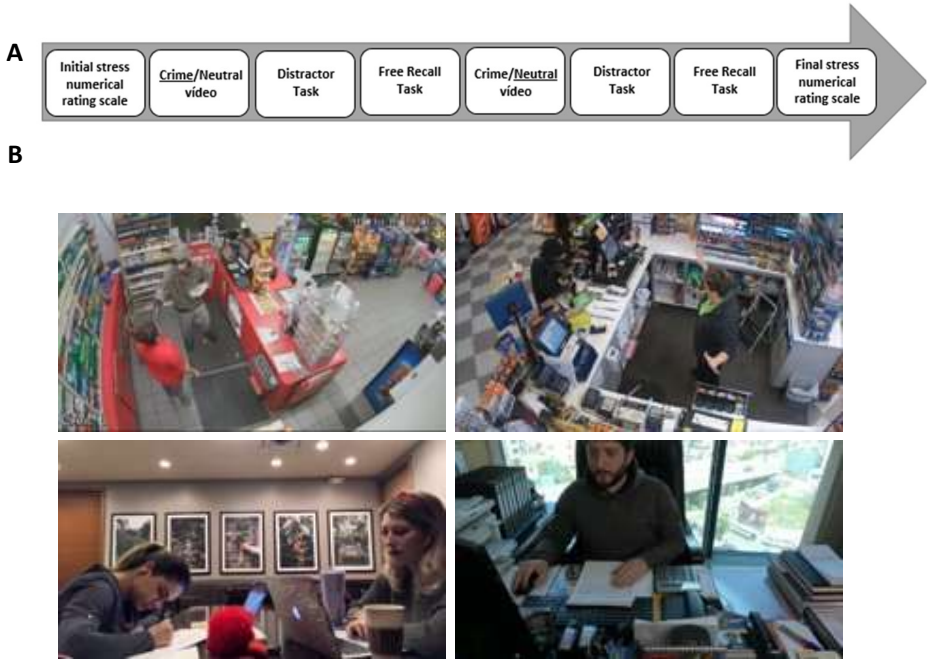

Figure 1. (A) Study procedure. In this case, the crime video was firstly shown and secondly the neutral video. The procedure was the same for first and second sessions differing in the time-of-day; also at the end of the second session, the participants were asked to complete the Depression, Anxiety and Stress Scale-21. **(B)** Extracts of the videos used in the experiment. The two crime videos (above) represent two armed robberies of convenience stores, both with a male perpetrator and a female victim (staff workers). The two neutral videos (bottom) correspond to common everyday situations; In one of the videos two young women were shown studying in a bar, using their respective computers and in the other video it was possible to visualize a man working in an office, also on the computer, with a city environment in the background.

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Data analysis

For the statistical analysis, the IBM SPSS Statistics 29 was used. A Multilevel Modeling (MLM) with maximum likelihood was conducted considering the repeated measures design used in the study. Based on the initial assessment of the participants' chronotype, an analysis was performed on the main effects and interactions between the timing of session (synchrony or asynchrony) and the type of video on participants' recall of details and memory errors (e.g., central and peripheral details correctly recalled and memory errors for central and peripheral details). Additional analyses were conducted considering stress, anxiety, and depression as control variables (Field, 2013).

Ethical Approval

This study was previously approved by institutional research committee at the CHUP/ICBAS [2021/CE/P032(P372/CETI/ICBAS)] and the guidelines of the Declaration of Helsinki were followed. Moreover, the project was submitted to the Data Protection of the University of Porto to verify if the procedure was in conformity with Regulation (EU) 2016/679 of the European Parliament and of the Council of April 27, 2016.

Results

Asynchrony and synchrony sessions significantly predicted the correct recall of central and peripheral details, as well as memory errors for both central and peripheral details. On average, participants exhibited better recall performance and made fewer errors in synchrony sessions compared to asynchrony sessions. Additionally, the type of video significantly predicted the correct recall of central and peripheral details, though not memory errors. Specifically, better retrieval of central details was observed when the videos depicted crime scenes, whereas superior recall of peripheral details occurred with

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videos depicting neutral scenes. Furthermore, an interaction between session timing and video type was observed for this dependent variable (see Tables 2 and 3). The pattern of results remained the same when controlled stress, anxiety, and depression.

Table 2. Descriptive statistics: Performance in synchronous and asynchronous sessions considering the type of video.

Dependent variable	Session	Videotype	*M*	*SE*
Central details correctly recalled	A	Crime	9.52	0.48
		Neutral	4.98	0.34
	S	Crime	11.27	0.51
		Neutral	5.50	0.35
Memory errors for central details	A	Crime	0.80	0.12
		Neutral	0.48	0.10
	S	Crime	0.48	0.09
		Neutral	0.27	0.07
Peripheral details correctly recalled	A	Crime	2.02	0.24
		Neutral	6.16	0.34
	S	Crime	2.41	0.28
		Neutral	8.09	0.56
Memory errors for peripheral details	A	Crime	0.11	0.05
		Neutral	0.41	0.09
	S	Crime	0.14	0.06
		Neutral	0.27	0.07

A – asynchrony; S – synchrony

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Table 3. Linear Mixed-Model Analysis: Synchrony and Asynchrony Sessions X Videotype [Fixed effects].

Parameter	*F,p*	Estimate	Test (df)	*p*	*95% CI*
Dependent variable: Central details correctly recalled					
Synchrony-Asynchrony Session (reference=asynchrony)	**7.12, .008**	**4.98**	**14.6(44)**	**<.001**	**4.29, 5.66**
Videotype (reference=crime)	**146.84, <.001**	**5.77**	**9.35(77.8)**	**<.001**	**4.54, 7.00**
Synchrony-Asynchrony X videotype	2.08, .151	-1.23	-1.44(156.8)	.151	-2.91, .455
Dependent variable: Memory errors for central details					
Synchrony-Asynchrony Session (reference=asynchrony)	**6.98, .009**	**.477**	**4.59(44)**	**<.001**	**.267,.687**
Videotype (reference=crime)	6.98, .009	.205	1.78(79.8)	.080	-.025, .434
Synchrony-Asynchrony X videotype	.330, .567	.114	.574(152.9)	.567	-.277, .505
Dependent variable: Peripheral details correctly recalled					
Synchrony-Asynchrony Session (reference=asynchrony)	**9.59, .002**	**6.16**	**18.36(44)**	**<.001**	**5.48, 6.84**
Videotype (reference=crime)	**171.98, <.001**	**-5.68**	**-9.12(64.43)**	**<.001**	**-6.93, -4.44**
Synchrony-Asynchrony X videotype	**4.26, .041**	**1.55**	**2.06(115.9)**	**.041**	**.063, 3.03**
Dependent variable: Memory errors for peripheral details					
Synchrony-Asynchrony Session (reference=asynchrony)	.641, .425	**.409**	**4.41(44)**	**<.001**	**.222, .596**
Videotype (reference=crime)	9.26, .003	-.136	-1.42 (84.7)	.160	-.328, .055
Synchrony-Asynchrony X videotype	1.26, .264	-.159	-1.12(144.4)	.264	-.440, .121

df = degrees of freedom. The pattern of results remains similar after controlling stress, anxiety, and depression.

Discussion

Key Findings

Regarding our hypothesis that morning- and evening-types would present a better memory performance when tested in the synchrony session when compared to the asynchrony session, our finding showed that participants had more central and peripherical details correctly recalled in the synchrony session and had more memory

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errors in the asynchrony moment. In the crime videos, participants presented more central details recalled when compared with peripherical details. In the neutral videos, more peripherical details were recalled. On average, participants exhibited better recall performance and made fewer errors in synchrony sessions compared to asynchrony sessions. The type of video significantly predicted the correct recall of central and peripheral details but did not predict memory errors. The pattern of results was similar when controlled stress, anxiety, and depression.

Comparison with other literature

The results allowed to corroborate, in general, the existence of a synchrony effect between the time-of-day for a task and the circadian peak performance of the participants, having influenced, in fact, the memory performance (Goldstein et al., 2007; Matchock & Toby Mordkoff, 2009). Indeed, synchrony effect has been widely studied in several areas, such as in academic settings (e.g., Rodríguez Ferrante et al., 2023; Tonetti et al., 2015). However, in forensic settings studies continue to be scarce; two exceptions are the studies of Yaremenko et al. (2021a; 2021b).

Similarly to previous research, these results also indicate that people remember more central than peripheral details when they experience a crime situation, since the high emotional charge events results in a marked focus of attention (Christianson & Loftus, 1987). On the other hand, in events with a reduced emotional charge, the attentional focus is more directed towards the surrounding environment (Christianson & Loftus, 1987; Pozzulo et al., 2008).

With respect to the influence of stress, anxiety, and depression in the memory performance, there is divergence in the literature. Some authors indicate that negative emotional states may influence cognitive performance, particularly memory (Gray, 2001;

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Luck & Vogel, 2013). If, on the one hand, there is literature that indicates that more pronounced symptoms of these negative emotional states may compromise the cognitive performance (Moran, 2016), on the other hand, there are authors who indicate that negative emotional states may result in greater sensitivity, attention, and ease in processing information (Harkness et al., 2005; Reisberg & Heuer, 2004). Therefore, the potential influence of participants' emotional states on memory performance justified the control of these variables (stress, anxiety and depression) in data analysis.

Strengths and limitations

This is one of the first studies that analyses the influence and differences between synchrony and asynchrony with chronotype in memory performance within the context of eyewitness testimony in Portugal, using experimental methodology and controlling variables that influence human memory (e.g., depression, anxiety, and stress). Being multidisciplinary research, it allowed an understanding of the confluence of several areas: Forensic Psychiatry/Memory and Testimony Psychology and Chronobiology. For this reason, this research is relevant in that it expands and unites the existing knowledge of Chronobiology with Memory Psychology.

However, this study has also some limitations. First, the use of videos may not generate the same levels of arousal and anxiety as when experiencing a real crime situation (Pozzulo et al., 2008). The existing differences between the results of the crime videos and the neutral videos indicate that, effectively, there was a difference in the level of arousal and that the crime videos induced negative emotions. Furthermore, considering the short time of the defined retention interval and the fact that encoding and retrieval took place in the same session, it would be interesting for future studies to try to understand the effects with longer retention intervals. Another limitation was the sample

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size, since the inclusion criteria (be morning-type or evening-type) and the procedure used for data collection, that has high risk of experimental death, hampered the use of a larger sample, which may have influenced the effect size. Also, the time of day for each session was too large (7:00-10:30 and 18:00-22:00). In future studies, circadian control markers could be recorded to provide higher validity of results (e.g., previous total sleep time, subjective alertness, subjective sleepiness). Thus, there is a need for more investigations in this area, using more representative and heterogeneous samples in order to ascertain the influence of other variables, such as sex and age. It could be also interesting to conduct other studies with different designs (e.g., to assess differences between homogeneous groups; between-subjects design).

Implications of the findings for future practice and research

The findings of this study provide important insights to the field of Forensic Psychology, demonstrating the importance of adapting the scheduling of crime witness interrogations to their chronotype as a tool for gathering more accurate testimony, considering that, in general, the results obtained allowed a greater and better knowledge about the influence that the synchronization between the time of day and the chronobiological clock can have on eyewitness memory performance. This study also confirmed the influence of emotional states on some of the results obtained, demonstrating the importance and necessity of measuring emotional states in practice, in questioning witnesses.

Future studies should investigate whether the effect would be the same for events with a positive emotional charge. Furthermore, considering the short time of the defined retention interval and the fact that encoding and retrieval took place in the same session,

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it would be interesting for future studies to try to understand the effects with longer retention intervals.

Conclusions

This research provides empirical evidence and can be a valuable contribution to future practices related to eyewitness testimony, as it allowed demonstrating the role that the synchrony effect may have in optimizing the performance of eyewitness memory.

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Compliance with Ethical Standards: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee at the CHUP/ICBAS [2021/CE/P032(P372/CETI/ICBAS)] and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Conflicts of interest: The authors declare they have no conflict of interest.

Informed Consent: Informed consent was obtained from all individual participants included in the study.

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