The Role of Individual Time Experience on Cognitive Knowledge Retrieval from Memory

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Abstract

This study investigates the influence of individual time experience on cognitive knowledge retrieval. Since time experience concepts like time perception has a relevant impact on memory processing and knowledge retrieval, this research aims to close the gap in understanding the effects of individual differences in time experience on these processes. We develop a theoretical model that integrates the Multi-Store Memory Model of Atkinson and Shiffrin (1968) and the Scalar Expectancy Theory of Gibbon (1977) and provide support through an empirical pilot study. In the study, the individual perception of time (the duration of the "now") was recorded and compared with the perception of the duration of past events. The results indicate a significant correlation between the perceived duration of events remembered from childhood and individual current time experience, emphasising the importance of individual time experience in cognitive knowledge retrieval. This study contributes to a new theoretical model and provides empirical evidence for the need for information systems that consider individual differences in time perception.

Keywords

Individual Time Experience, Cognitive Knowledge Retrieval, Memory Processing

1. Introduction

In today's digital age, the effectiveness and acceptance of information systems are highly dependent on their ability to adapt to users' individual preferences and expectations. According to Delone and McLean [1], McLean, Petter [2] and Venkatesh, Thong [3], information systems designed to match users' perceptions are more likely to achieve higher acceptance, satisfaction and efficiency. This alignment is particularly important in knowledge retrieval, where the system design must be adapted to the nuanced ways in which users perceive and process information over time.

The experience of time is a fundamental aspect of human cognition that significantly influences dynamics between work structures, people, technologies and tasks, either facilitating or hindering collaboration [4]. Time experience is affected by various cognitive processes, including attention, comparison and memory processes, which are crucial for effective knowledge retrieval [5]. However, existing information systems often overlook the variability in individual time experience (ITE), leading to a gap in the effectiveness of these systems. The literature on cognitive knowledge retrieval emphasises how environmental factors and internal cognitive processes, such as encoding and rehearsal, influence knowledge retrieval [6]. At the same time, human cognition research emphasises the impact of individual time perception on memory processing [5].

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Although the mechanisms of memory and perception have been thoroughly investigated, the influence of ITE on knowledge retrieval from memory has not yet been sufficiently explored [4]. This gap highlights the need for a theoretical model and empirical investigation that explicitly considers ITE as a variable influencing knowledge retrieval.

The present study aims to address this gap by investigating the influence of individual time perception on knowledge retrieval. We assume that a person's time experience influences their retrieval of past experiences and information. Our central research question is: *Does individual time experience influence cognitive knowledge retrieval?*

To answer this question, we aim to develop a theoretical model incorporating ITE and conduct an initial empirical pilot study to validate the relationships between time experience and memory retrieval.

Our theoretical framework is based on established cognitive models, the Multi-Store Memory Model (MSMM) by Atkinson and Shiffrin [6] and the Scalar Expectancy Theory (SET) by Gibbon [5]. These models provide a basis for understanding how information is processed, stored and retrieved in the human brain. By integrating these models with insights from the internal clock theory [7] and other findings on time experience, we aim to develop a comprehensive model that considers individual differences in time perception for cognitive knowledge retrieval.

The study pursues a mixed methods approach that combines the development of a theoretical model with an empirical pilot study. The pilot study will include a survey to measure participants' experience of time and its effect on memory retrieval. The collected data will be analysed to identify patterns and validate the proposed theoretical model.

This research contributes to cognitive knowledge retrieval by providing a new theoretical model recognising ITE. In addition, the empirical results of the pilot study will provide initial evidence to support the model. Ultimately, this study will provide a research agenda aiming to improve the design of information systems to better account for individual differences in time experience.

The remainder of this manuscript is organised as follows: In the next section, we provide a detailed review of the literature on cognitive knowledge retrieval and time experience. We then present the development of our theoretical model and the methodology for the pilot study. The results section provides an overview of the empirical study's findings, followed by a discussion interpreting these findings in the context of the proposed model. Finally, the conclusion summarises the study's contributions and makes suggestions for the future.

2. Theoretical Background

2.1. Cognitive Knowledge Retrieval: Multi-Store Memory Model

Knowledge retrieval, a fundamental aspect of human cognition, involves accessing and extracting stored information. Understanding this process from a psychological perspective requires examining how cognitive processes, such as memory and perception, facilitate effective knowledge retrieval. Cognitive psychology provides important insights into how people process, store and retrieve information and knowledge. This field highlights the importance of understanding the underlying mechanisms of memory, perception and attention. Ingwersen [8] emphasises that each important step in retrieving knowledge can be viewed as a problem-solving task involving perception, information processing, representation and categorisation of knowledge [8].

Human memory is divided into several systems, each crucial in retrieving knowledge. Dual process models, as discussed by Smith and DeCoster [9], assume that humans have two memory systems: one that slowly learns general regularities and another that quickly forms representations of unique events. These models suggest that associative retrieval from the slow-learning system is an effortless mode of processing, whereas deliberate retrieval of explicit rules requires more effortful processing [9]. Rugg and Wilding [10] go further into retrieval processing by examining the neural basis of episodic memory. They identify different retrieval processes, such as retrieval mode, effort, and success, investigated through brain imaging studies. Rugg and Wilding [10] emphasises the importance of understanding these processes' neural correlates to understand better how memory retrieval works.

Cognitive models are essential for predicting user behaviour and improving the design of knowledge retrieval systems. Sutcliffe and Ennis [11] propose a cognitive theory of knowledge retrieval that incorporates user strategies and correspondence rules to predict behaviour at different task stages. This approach aims to tailor knowledge retrieval systems to users' cognitive processes and information needs [11].

Advanced research integrates cognitive psychology with other disciplines to improve knowledge retrieval. Bhatia, Choudhary [12] provide an overview of cognitive knowledge retrieval concepts and emphasise the role of perception, attention, interpretation and memory for understanding user behaviour and improving retrieval. This approach combines cognitive psychology with information science for more effective retrieval techniques [12].

The Multi-Store Memory Model (Figure 1), proposed by Atkinson and Shiffrin [6], offers a framework for understanding these cognitive processes and a deeper understanding of how information is processed, stored within and retrieved in the human brain. It describes how information flows through three main stages of memory: sensory memory, short-term memory (STM), and long-term memory (LTM). This model emphasises the sequential processing of information involving perception, encoding, rehearsal, and retrieval. Perception involves the initial recording of information from the environment through sensory organs. This information is then processed and encoded into a format that can be stored in memory. Rehearsal refers to the retention of encoded information in either short-term or LTM, depending on the duration and importance of the information. Finally, retrieval is accessing stored information and bringing it into consciousness when needed [6].

Sensory memory is the first phase in which sensory information from the environment, such as visual and auditory stimuli, is stored for a short period of time, usually less than a second. This short retention time enables the initial processing of sensory impressions before they are either transferred to the STM or forgotten if sufficient attention is paid [6].

STM holds a small amount of information for a limited duration, usually around 20-30 seconds. It is essential for the temporary storage and processing required for cognitive tasks like thinking and understanding. Information in STM can be maintained through rehearsal, which involves the repeated verbalisation or mental repetition of information. Without rehearsal, information may be lost due to decay or interference. Effective rehearsal can facilitate the transfer of information from STM to LTM [6]. The STM can be further described as a working memory, taking into account the cognitive tasks of the memory, such as language comprehension, learning, and reasoning [13].

LTM stores information for extended periods, ranging from minutes to a lifetime, with potentially unlimited capacity. Information in LTM is organised semantically, based on meanings and relationships between concepts. The encoding, consolidation, and retrieval processes are crucial for the effective functioning of LTM. Encoding involves converting information into a storable format, consolidation stabilises memory traces after initial capture, and retrieval is accessing stored information when needed [6].

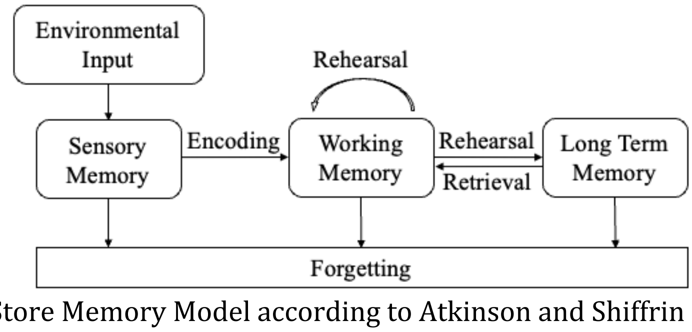

Figure 1: The Multi-Store Memory Model according to Atkinson and Shiffrin [6].

2.2 Individual Time Experience: Scalar Expectancy Theory

Time experience is a fundamental aspect of human cognition, shaping our perception of events, influencing our decision-making processes, and contributing to our understanding of the world [14-16]. Individual time experience refers to the individual feeling of how quickly time passes and estimates and preferences of time intervals.

ITE encompasses multiple dimensions that shed light on how individuals interact with each other and information systems. One key dimension is time perception, which involves the subjective interpretation of event durations [17]. Another dimension is the estimation of time intervals, focusing on how individuals estimate the duration of events before, during, or after they occur [18]. Recognising that time is influenced by social and individual factors [19], ITE also includes normative time, where individual perceptions shape understandings of how time should be interpreted [20]. This leads to the dimension of time interval preference, reflecting preferences for event durations, which can pertain to the past, present, or future [21]. These preferences significantly impact interactions with others and systems. While time interval preferences are crucial, they have not been extensively studied, though research indicates that time interval estimations, which form the basis for these preferences, are stable over time [22].

To better understand the intricacies of ITE, it is essential to explore the underlying mechanisms that shape our perception of time. One of the most important theoretical frameworks explaining the mechanisms behind ITE is Treisman's [7] theory of the internal clock, a fundamental component that enables the subjective experience of time sequences. Understanding this theory is crucial as it forms the basis for more comprehensive models, such as Gibbon's [5] Scalar Expectancy Theory.

The internal clock theory proposes an internal timing mechanism in the brain. This mechanism enables humans to perceive time and estimate the duration of events and intervals. It is assumed that these impulses represent the subjective experience of the passage of time [7]. The internal clock theory provides the basis for the pacemaker-accumulator model (PAM), a specific mechanism within the SET that describes how clock ticks are generated by a pacemaker and collected in the accumulator, leading to the perception and estimation of time intervals and the experience of time. As can be seen in Figure 2, the SET model includes seven key components: The pacemaker, the switch, the accumulator, the STM (according to Baddeley and Hitch [13] better working memory), the LTM, the decision-making process and the following observed behaviour.

This SET model involves three main stages: the clock, memory, and decision-making processes. The clock stage begins with the pacemaker, which generates pulses regularly. These pulses are then managed by a switch, which controls their flow into an accumulator. The accumulator collects the pulses generated by the pacemaker, with the number of accumulated pulses representing the perceived duration of an event [23]. In the memory stage, pulses accumulated for a current event are initially stored in working memory. Some of these pulses are then transferred to LTM for future comparisons and decisions [24]. The decision-making stage involves a comparison process, where the number of pulses in working memory is compared with reference durations stored in LTM. Based on this, decisions about the perceived duration influence observed behaviour [25].

Individual differences in time perception can be attributed to variations in pacemaker speed and memory processes. These differences are influenced by several factors, including arousal, attention, and genetic makeup. Emotional states, for instance, can affect the speed of the pacemaker. Higher arousal levels increase the pacemaker's pulse rate, leading to a perception of longer durations [26]. Attention also plays a critical role, as the gate or switch mechanism can be influenced by where attention is focused. Diverting attention can delay the switch closure, altering pulse accumulation and thus distorting time perception [27]. In addition, genetic factors, such as variations in genes related to neurotransmitter systems such as serotonin, can influence the properties of the pacemaker and thus cause individual differences in time perception [28].

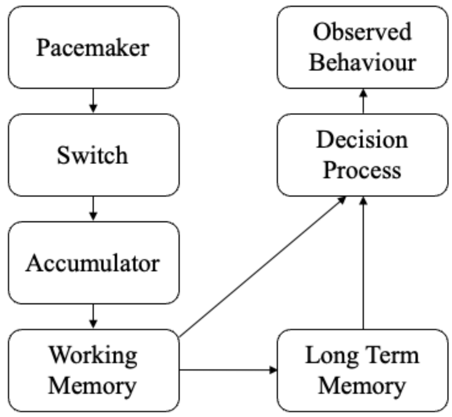

Figure 2: The Scalar Expectancy Theory Model according to Gibbon [5].

In addition to insights from Treisman's Internal Clock Theory and the SET, other models offer varied perspectives on individual time perception. The Attentional-Gate Model by Zakay and Block [29] introduces an attentional gate mechanism that regulates pulse flow from the pacemaker, emphasising the role of attention in perceived duration. The Behavioural Theory of Timing by Killeen and Fetterman [30] explains time perception through behavioural processes, focusing on attention, memory, and temporal information processing. The Multiple-Time-Scale Timing Model by Staddon and Higa [31] suggests a memory dynamics-based approach, where the brain uses memory traces on different scales to measure time intervals. Additionally, some researchers view time perception as an emergent property of specific systems like visual or motor systems rather than relying on an internal clock. These models collectively enhance our understanding of the complex and varied mechanisms behind individual time perception, highlighting the interplay of cognitive, behavioural, and physiological factors.

2.2. Development of an Individual Time-Memory Model

To better consider the individuality of time experience in the processes of memory storage and retrieval, it is necessary to combine the MSMM [6] with the SET [5]. The combination of these models allows for a more comprehensive understanding of how information is processed and stored in the human brain, emphasizing the role of ITE in these cognitive processes.

Both models share fundamental principles, particularly the distinction between working and LTM. The MSMM assumes that perception involves individual sensory systems' absorption of environmental information, which then process this information. Attention as a cognitive resource determines which information is transferred to working memory and which is immediately discarded. However, this model does not adequately account for how ITE influences knowledge rehearsal and retrieval.

Incorporating the PAM from the SET enhances the consideration of individuality. This model introduces internal processes that lead to individual time perception and groups the perception by considering external influences in time intervals, significantly impacting memory. It accounts for varying perceptions of the environment and elucidates how internal pacemakers affect working memory, influencing the rehearsal and retrieval processes between working and LTM.

The newly established Individual Time-Memory Model (Figure 3) starts with the processing of environmental input that sensory memory perceives, as described in the multi-store memory model. Information from sensory memory is then included in the working memory if it receives sufficient attention. The process of encoding is influenced by the rhythm of the pacemaker, switch and accumulator logic, as described in SET. The internal clock mechanism influences the working memory's inclusion by modulating the information's perceived duration and significance. The accumulator influences as a reflector of the individual perception of time not only the information encoding but also moderates the working memory [5] and, finally, the information retrieval from working memory and LTM, which leads to a specific decision.

Rehearsal processes maintain information in the working memory, facilitating its transfer to the LTM. Subsequently, information is stored in LTM over longer periods of time. As a result, retrieval processes from LTM are influenced by individual time perception. Finally, the decision-making process, which relies on information from working and LTM, culminates in observed behaviour. Individual time perception impacts decision-making by comparing current pulses in working memory with reference durations stored in LTM.

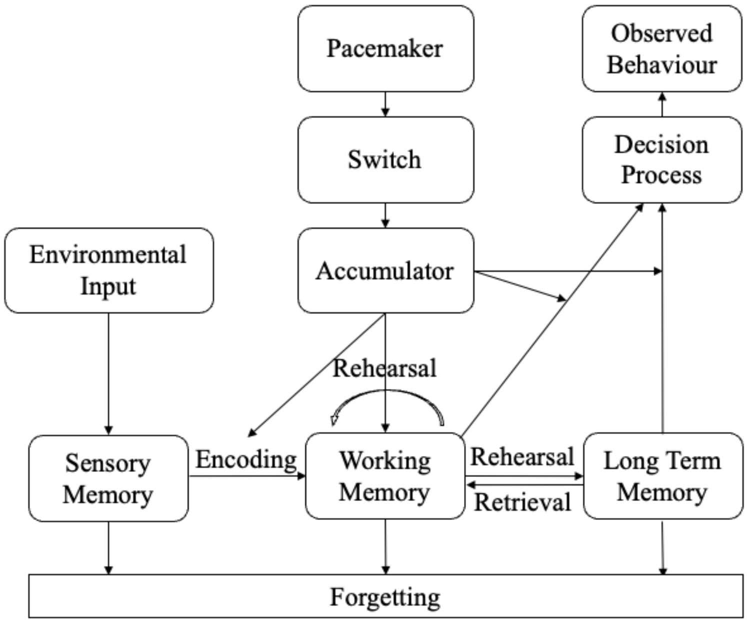

Figure 3: The Individual Time-Memory Model (based on Atkinson and Shiffrin [6] and Gibbon [5]).

The combined model enhances our comprehension of memory processes by integrating the individuality of time experience. It demonstrates how internal and external perceptions influence knowledge encoding, storage, and retrieval. This integrated approach provides a holistic view of cognitive processes, effectively bridging the gap between environmental input and observed behaviour through the lens of ITE.

Based on the Individual Time-Memory Model and theoretical considerations, the hypothesis can be derived that individual experience of time influences the perceived duration of past events from memory. This implies that the subjective perception of time plays a key role in cognitive knowledge retrieval. As individual differences in the perception of time can lead to different memory processes, it is plausible to assume that people who perceive the present as longer or shorter also remember the duration of past events differently.

We, therefore, hypothesise that *Individual time interval preferences are related to the duration of past events that are retrieved from memory.*

3. Research Method

3.1. Procedure

We conducted a survey using a structured questionnaire to investigate participants' experience of time. The aim was to gather information about the perceived duration of different experiences. Participants were recruited from Clickworker, a crowdworking platform, to ensure a diverse demographic representation.

Participants were first asked to recall an event from their childhood, describe it in words and estimate the duration in minutes. The participants were then asked to define how long they perceive the present moment ("now") instead of the past and future and to determine their individual experience of time. In addition, participants were asked to state their age (in years) and gender. The responses were collected and analysed to understand the subjective perception of time across different experiences and demographic characteristics. Chi-square tests were used to analyse the significance of demographic variables on the perception of time. The aim of this analysis was to confirm the hypothesis that personal characteristics influence the perception of time intervals.

3.2. Participants

We used G*Power to calculate the necessary sample size a priori. For the calculation, we used a medium effect size of 0.3, an error probability of 0.05 and a desired statistical power of 0.8, which are typically recommended values for behavioural science [32]. The resulting minimum sample size is 84. We recruited participants through the crowdworking platform Clickworker and compensated them for their participation. To ensure the quality of our data, we followed the recommendations of Goodman, Cryder [33]. As part of this process, we included attention checks in our study, excluding some datasets.

116 individuals participated in our study and passed the attention checks. After data cleaning, 103 participants could be used for analysis. G*Power analysis indicated a statistical power of 0.88. Among the 103 participants, 37 were males and 66 females. The participants had an average age of 38.00 years and a standard deviation of 9.55 years.

3.3. Data Analysis

To analyse the data, we conducted correlation tests to identify initial results and determine potential relationships. The variables in our study included participants who reported perceived durations for different types of experiences (childhood events and the perception of "now"). Age and gender were included as control variables.

We calculated Pearson correlation coefficients to determine the strength and direction of relationships between the demographic variables and the perceived durations. This analysis aimed to reveal the relationship between individual perception of time and memory retrieval. The correlation tests provided initial insights into the data, enabling us to detect significant associations that could inform further analysis and hypothesis testing. These initial results are crucial for understanding the underlying patterns in participants' time perception and guiding more detailed subsequent analyses.

4. Results

4.1. Descriptives

Table 1 below shows the descriptive results of the items examined in the analysis.

Table 1
Descriptive results

Item	N	Min.	Max	Mean	SD
Perceived Childhood Experience (min)	103	1	3.63	119.21	457.35
Perceived now (min)	103	0	2.63	53.32	271.30
Age	103	21	63	38.00	9.55
Gender	103	1	2	1.64	0.48

4.2. Hypotheses tests

The following Table 2 shows the results of the correlation analysis. The results support the hypothesis and research question that individual experience of time is related to the duration perception of past events and, thus, cognitive knowledge retrieval. The perceived time of the childhood experience (in minutes) correlates significantly positively with the perception of "Now". There are no significant correlations between the perceived time of the childhood experience and the other variables.

Table 2
Correlations

Item		Perceived Child-hood Experience (min)	Perceived now (min)	Age	Gender
Perceived Childhood Experience (min)	Person corr.	1	0.892**	-0.095	0.078
	Sig. (2-taled)		0.000	0.340	0.433
Perceived now (min)	Person corr.		1	0.027	0.107
	Sig. (2-taled)			0.790	0.281
Age	Person corr.			1	0.153
	Sig. (2-taled)				0.122
Gender	Person corr.				1
	Sig. (2-taled)				

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Note: n=103, confidence intervals can be found in the appendix.

5. Discussion

The results of this study emphasise the important role that individual experience of time plays in cognitive knowledge retrieval. The positive correlation between perceived childhood experience and perception of the "now" suggests that individuals with a strong sense of the present are more likely to remember past events as lasting longer. This result supports our hypothesis that personal experience of time is related to the duration of past events is retrieved from memory.

The analysis revealed that while there is a significant correlation between the perceived time of childhood experiences and the perception of "now", there are no significant correlations between childhood experiences and the other variables, age and gender. This suggests that how individuals experience time is more crucial to memory retrieval than demographic factors.

The results contribute to our understanding of the subjective nature of time experience and its influence on memory recall. The lack of significant correlations with age suggests that individual time experience is a stable trait that does not necessarily change. This stability emphasises the importance of considering individual differences in time experience when developing information systems.

These findings have implications for cognitive psychology and the design of knowledge retrieval systems. Understanding how ITE affects knowledge retrieval can drive the development of personalised and efficient information systems. Such systems could adapt to users' ITE patterns and thus improve user satisfaction and efficiency.

6. Research Agenda

The results of this study provide important insights into the relationship between individual experience of time and cognitive knowledge retrieval, which are anchored in the theoretical frameworks according to the MSMM by Atkinson and Shiffrin [6] and the SET by Gibbon [5]. The positive correlation between the perceived duration of childhood experiences and the experience of the "now" is consistent with the new established Individual Time-Memory Model. However, the topic of this initial pilot study needs to be further explored in both depth and breadth to understand individual experience of time and knowledge retrieval fully. More comprehensive research is also essential to understand the impact of ITE on individuals and the information systems they interact. The following sections will outline a research agenda, detailing the recommended directions for future studies.

Understanding how individuals perceive and experience time is fundamental to cognitive research. This exploration delves into the complexities of time experience, estimation of time intervals, normative time, and time interval preferences.

- Time interval estimation refers to how people estimate the duration of events. The factors that influence these estimates examining the accuracy and consistency of people's time interval estimates in different contexts and tasks, need to be investigated. The insights gained from this research can help shed light on the cognitive mechanisms behind time estimation and its variability.
- Normative time explores how social and individual factors shape understanding standard or expected event durations. There is a need to examine differences in the experience of normative time and their effects on cognitive processes. Understanding these differences is crucial for developing a comprehensive overview of how the experience of time is influenced by social and cultural contexts.
- Time interval preference is about analysing people's preferred duration of events and how stable these preferences are over time. Research must analyse how these preferences affect interaction with information systems and decision-making processes. By exploring time interval preferences, we can improve the design of systems and processes to align them with user expectations and increase overall efficiency and satisfaction.

The experience of time plays a pivotal role in the processes involved in knowledge retrieval. This section explores how individual differences in time experience impact memory processes and cognitive load, influencing the efficiency and effectiveness of knowledge retrieval.

- Memory processes encompass the encoding, rehearsal, and retrieval of knowledge. Research must investigate how differences in time experience influence these memory processes in both working and long-term memory. By analysing these interactions, we can gain insights into how time experience affects memory performance and develop methods to enhance memory retrieval based on ITE profiles.
- Cognitive load refers to the mental effort required to process information. Research must investigate the cognitive load associated with different time experiences and its effects on knowledge retrieval. By identifying how different patterns of time experience influence cognitive load, we can develop strategies to mitigate these effects and ultimately improve the efficiency and effectiveness of information-seeking systems. Understanding the cognitive load associated with time experience can lead to more user-friendly designs and processes customised to individual cognitive abilities.

Personalising information systems to adapt to ITE can improve their user experience and usability. This section addresses the development of adaptive user interfaces that accommodate different time experience patterns and the creation of predictive models to anticipate user behaviour.

- The design of user interfaces plays a decisive role in adapting to different time experience patterns. Research needs to focus on developing user interfaces that improve the user experience and usability of the system by tailoring the presentation of information to ITE. By exploring visual and auditory signals, we can develop user interfaces that are intuitive and responsive to users' temporal preferences, improving the overall interaction with information systems.
- Predictive models are essential for predicting user behaviour based on time experience. This research area is about developing models that improve the accuracy and efficiency of knowledge retrieval by integrating time experience data. By integrating these predictive models into information systems, we can provide personalised

recommendations and support and ensure that users receive timely information that meets their needs and expectations.

Integrating the understanding of ITE into cognitive models and practical applications holds significant potential for advancing both theoretical frameworks and real-world practices.

- Extending existing cognitive models to integrate ITE enables a more comprehensive understanding of cognitive knowledge retrieval processes. Research must investigate the interplay between time experience and other cognitive functions, such as attention and decision-making. By incorporating time experience into cognitive models, we can better understand how temporal factors influence cognitive processes, leading to more accurate and robust theoretical frameworks.
- Practical applications focus on implementing research findings in real-life scenarios to improve outcomes in different areas. For example, understanding time experience can improve learning outcomes in education by tailoring teaching strategies to the temporal preferences of individual students. In healthcare, accurate time experience is critical to decision-making, and training programmes can be developed to improve the temporal accuracy of professionals. By applying insights from time experience research to practical contexts, we can develop measures and strategies that improve efficiency, effectiveness and user satisfaction in different areas.

7. Conclusion

7.1. Theoretical contribution

This study contributes to the theoretical understanding of cognitive knowledge retrieval by integrating the MSMM [6] and the SET [5] with insights on ITE. By developing the Individual Time-Memory Model, this research offers a new perspective on how individual differences in time perception influence memory processes, including encoding, rehearsal, and retrieval. This model enhances the comprehension of cognitive processes by accounting for the subjective nature of time experience, bridging the gap between environmental inputs and observed behaviours.

The empirical results of the study provide further support for the theoretical model. The significant correlations between the individual experience of time and the perceived duration of past events confirm the relationships proposed in the individual time memory model. The positive correlation between the perceived childhood experience and the perception of the "now" supports the hypothesis that the personal perception of time influences memory retrieval. These results provide initial evidence that individual differences in time experience significantly influence cognitive knowledge retrieval, emphasising the need to include these variables in theoretical models. This empirical validation strengthens the model's applicability and encourages further research to explore these dynamics more deeply.

7.2. Practical contribution

The practical implications of this study are important for the design and implementation of information systems. By recognising the role of ITE in cognitive knowledge retrieval, system designers can develop more personalised and efficient knowledge retrieval systems. These systems can be tailored to users' unique time experience patterns, improving user satisfaction and system effectiveness. For example, adaptive user interfaces that adjust to individual temporal preferences can improve user interaction and performance. In addition, the findings from this study can inform the development of training programmes and decision-making processes in various fields, such as education and healthcare, by incorporating strategies that align with individuals' temporal preferences and cognitive abilities.

7.3. Limitations

This study has some limitations that should be acknowledged. Firstly, the empirical investigation is based on a pilot study with a rather small sample, which may limit the generalizability of the results. Future studies with more diverse samples must validate and extend the results. Secondly, the study relied on self-reported measures of time experience and memory, which may be subject to bias and inaccuracy. Objective measures and longitudinal studies could provide more robust data in future studies. Finally, considering only age and gender as control variables may overlook other variables that could influence the individual experience of time and cognitive knowledge retrieval. Expanding the research to include additional factors, such as cultural background and cognitive styles, would allow for a more comprehensive understanding of the phenomenon.

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Appendix

Additional data can be found online in an open-access data repository:
https://doi.org/10.17605/OSF.IO/SGEJK