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Original scientific paper

The Influence of the Period of Retention on the Reliability of Episodic Memory in the Context of Testimony

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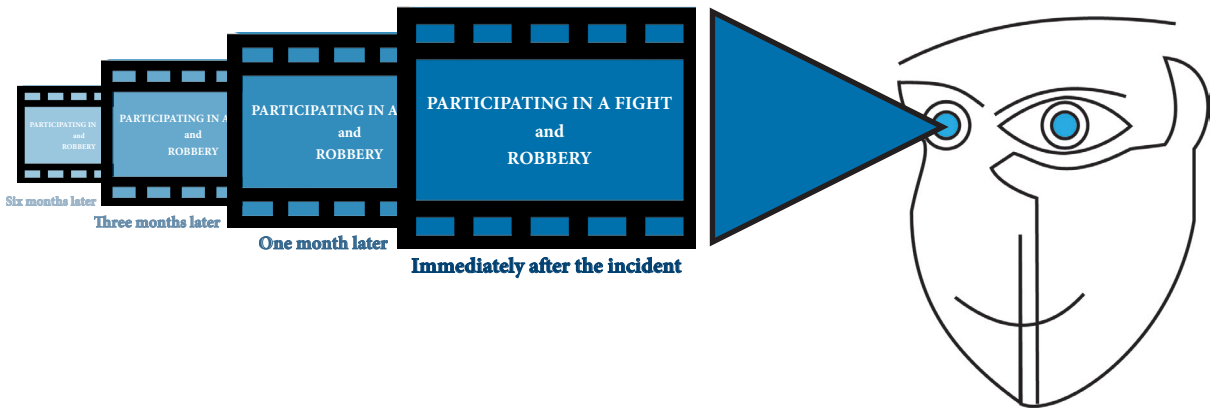
Abstract: The paper presents a study that aimed to examine the reliability of episodic memory by varying the retention time from the moment of initial observation of two incidents to the moment of communicating what was actually remembered. Ninety (90) students aged 21-26 from the University of Criminal Investigation and Police Studies participated in the research (50 males and 40 females). The interval of retention presented an independent variable on four levels: immediately after watching a recording, after 1 month, after 3 months and after 6 months. The accuracy of recall, or remembering one aspect of the incident (characteristics of the event, characteristics of the perpetrators and characteristics of the victim) was a dependent variable. Results suggest that memory accuracy declines dramatically after a month, but also after three and six months, when the downward trend in memory accuracy is less pronounced. Regarding the degree of confidence in memory accuracy, the pattern of results is practically identical to that of memory accuracy. As a whole, the results indicate that the retention interval strongly affects both accuracy and certainty in memory accuracy, regardless of the type of crime and the characteristics being evaluated.

Keywords: eyewitness memory, period of retention, testimony.

Graphical abstract



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INTRODUCTION

During the first half of the 20th century studies on human memory were mainly based on memorising meaningless syllables, based on the work of Ebbinghaus. Things gradually began to change from the end of the 1960s when a larger number of researchers emerged engaged in the study of perception and memory. Interest in this theme continued in the 1970s, especially thanks to the work of American psychologist Elizabeth Loftus. Research carried out by Loftus and other researchers, especially psychologists (Blackwell-Young, 2008; Koriat et al., 2000; Loftus, 2003), raised greater awareness of the importance of wrong or inaccurate/incorrect memories and the potential consequences, especially in the context of testimony (Shapira & Pansky, 2019). What Loftus especially indicated was that starting from a wrong premise by which the eyewitness "recalled" from memory something which they had actually seen, in essence the eyewitness remembers a reconstructed performance, that is, their own reconstruction of the event, which can often be accompanied by certain errors (Loftus, 1975). "Project Innocence", undertaken in the USA in the mid-1990s, testified to eyewitnesses being unreliable sources of information regarding a criminal incident (Garrett, 2011). In many cases, the project showed (thanks to DNA testing) that many people had been wrongly convicted on the basis of honest, but mistaken testimony (Innocence project, 2018; Scheck et al., 2000).

In numerous psychology studies (Howitt, 2009), several significant conclusions were reached supporting the issue that memory is not perfect and does not function like a video recording. Firstly, the eyewitness of a criminal incident can only focus on its individual parts. Secondly, an eyewitness does not succeed in remembering the whole incident. Finally, in trying to remember information about a criminal incident, eyewitnesses cannot remember everything, so they may "add" some information that corresponds to their expectations.

In criminal law and criminology theory there is increasing debate about the importance of eyewitness testimony and the assessment of their truthfulness. Each person has different biological, physiological, and psychological characteristics, whereby one should bear in mind so-called individual differences in sense organs, as well as the subjectivity of each statement resulting from perceptual preparedness, or abilities of observation and expression (Baić & Deljkić, 2019; Ivanović & Baić, 2019). A witness statement can be accurate or inaccurate, both in total and in its individual segments. An inaccurate witness statement is sometimes the consequence of a deliberate lie about the target event (Vrij et al., 2017), while a wrong/mistaken statement can be the result of wrong perception, poor memory, or of a number of factors (Gustafsson et al., 2019), such as factors relating to the criminal incident itself (Bornstein et al., 2012), factors connected with the eyewitness (Deffenbacher et al., 2004; Pozzulo & Warren, 2003; Wise & Safer, 2004) and factors that come to light after a criminal incident (Morgan et al., 2013; Shapira & Pansky, 2019). Alongside many variables which influence the accuracy of an eyewitness statement (Blackwell-Young, 2008), eyewitnesses' memory depends to a large degree on the conditions in which their interview is carried out, the way in which they are interviewed, the way in which questions are formulated, the type and order in which questions are asked, but also from how much time has passed from the moment when the event was observed to the moment when the witness testified in the police or the prosecutor's office (Evans & Fisher, 2011). Research shows that it is most optimal for the witness to be examined as soon as possible, and no later than four months from the moment the criminal event is observed (Penrod & Cutler, 1995; Shepard, 1983). This is also important in the context of witness recognition of perpetrators, as the results of

some studies suggest that over time the accuracy of identification decreases and the number of misidentifications increases (Penrod & Cutler, 1995; Krafka & Penrod, 1985; Malpass & Devine, 1981). Thus, the results of the mentioned research suggest that the quality of memory or the quality of information obtained can be significantly affected by the passage of time from the event to the testimony (retention interval).

Given that the objectivity of testimony remains one of the key issues of proof in criminal proceedings, it is an indisputable fact that research dealing with problematic testimony should be conducted (Wells et al., 2006; Wixted et al., 2018), especially due to the fact that the prosecution and the police, in the absence of evidence, rely heavily on witnesses to establish the facts of the crime. This study examines the effects of several variables such as period of retention, memory accuracy, and confidence in memory accuracy.

Aims of the Study

The main objective of this research was to examine the reliability of episodic memory by varying the period of retention from the moment of initial observation of the event-incident to the moment of communicating what was actually observed and remembered. Based on the results of previous research (Pansky, 2012; Pansky et al., 2011; Pansky & Nemets, 2012; Shapira & Pansky, 2019), it can be expected that the number of details that respondents remember about the perceived event will decline over time, more precisely that the memory will decrease by varying the period of retention from the moment of initial observation of the event-incident, to the moment of communicating what was actually observed and remembered.

The secondary aim of this research relates to examining certainty in the precision of memory over time, as well as correlations between the precision of memory and certainty in the precision of memory, with regard to observed events. We viewed the precision of certainty in memory reliability as agreement between the certainty and accuracy of respondents' answers (Sarwar et al., 2014). Although research on the degree of certainty in memory accuracy have been divided (Shapira & Pansky, 2019), respondents can be expected to show a lower degree of certainty. Some studies show a consistent association between assessing confidence in one's own memory and the accuracy of memory (Odinot & Wolters, 2006; Wixted & Wells, 2017). However, other research reports less self-confidence especially when it comes to detailed and descriptive information, which relates to descriptions of persons and objects (Ibabe & Sporer, 2004; Sarwar et al., 2014).

METHOD

Sample and Procedure

The sample comprised 90 students (50 males and 40 females) from the third year of the University of Criminalistic Investigation and Police Studies in Belgrade. The respondents completed a questionnaire to earn additional credits in courses of Criminal Psychology and Tactic of providing statements. All respondents had normal vision or vision corrected to normal. The age of the respondents ranged from 21 to 26 years (MOD = 23). The required sample size was determined in G*Power 3 (Faul et al., 2007). The research design used in this study identified significant differences that have a great effect ($\acute{\eta}^2_p$ = .14; Co-

hen, 1988) with 80% statistical power for α = .05 and required 71 subjects. The use of the student sample, as well as the sample size, is consistent with the size and structure of other research samples within the research area of interest using a similar research design (e.g., Gustafsson et al., 2019; Lindholm et al., 2018; Sarwar et al., 2014; Shapira & Pansky, 2019).

The main effect of gender was not statistically significant in the case of event characteristics (λ = .94, F [86/2] = 1.21, p > .05, $\acute{\eta}^2_p$ = .041), executors (λ = .95, F [86/2] = 1.18, p > .05, $\acute{\eta}^2_p$ = .038) and victims (λ = .93, F [86/2] = 2.02, p > .05, $\acute{\eta}^2_p$ = .056). Also, the interaction of repeated measurements and gender was not statistically significant in the case of event characteristics (λ = .96, F [86/3] = 1.16, p > .05, $\acute{\eta}^2_p$ = .039), executors (λ = .96, F [86/3] = 1.16, p > .05, $\acute{\eta}^2_p$ = .039) and victims (λ = .92, F [86/3] = 2.34, p > .05, $\acute{\eta}^2_p$ = .076), resulting in gender not being included in further analysis.

The data was collected at the University of Criminal Investigation and Police Studies in Belgrade in 2019, over a period of six months. Before participating in the survey, respondents were informed that they would watch two audio-visual recordings showing offenders involved in a fight and in a robbery, after which they would answer some questions relating to their memory of these incidents. The survey was anonymous and voluntary, with all respondents signing informed consent before participating in the survey. The data was collected at four time points: immediately after watching the audio-visual recording (T1), after one month (T2), after three months (T3) and after six months (T4). Respondents viewed the audio-visual recording only once, before the first measurement.

Stimuli

The stimuli were two video-audio recordings of the criminal offence of Participating in a Fight (Article 123) and the criminal offence of Robbery (Article 206; Criminal Code of the Republic of Serbia). In the case of the first crime, which occurred on the street, three male offenders and one male victim were involved. All three minors kicked the victim with the use of physical force. In the case of the second offence, two adult male perpetrators and one female victim were involved in a robbery which took place at the gas station. The first audio-video was 36 seconds long and the second was 134 seconds long. Respondents viewed video-audio recordings via a projector, ensuring adequate image and sound quality and intensity so that these factors would not affect the subjects' understanding of the stimulus material. Respondents watched the mentioned video-audio recordings for the first time during the research.

Instruments and Response Coding

The response protocol created for this research was an instrument used for data collected on the accuracy of memory, and certainty in the accuracy of respondents' memories of the two incidents. The protocol included a total of 16 questions with different answer formats, such as open-ended questions and convergent questions with one correct answer, to enable the respondent to give answers according to his or her own memory, taking care not to suggest answers in any way. The protocol consisted of four parts: The first part dealt with the main characteristic of the incident and covered 7 questions (e.g. "How many people were on the recording?"); the second part concerned the characteristics of the perpetrators (one description for each perpetrator) and covered 4 questions (e.g., "What was the [physical] constitution [makeup] of the perpetrator?"); the third part concerned the char-

acteristics of the victim and included 4 questions (e.g., "What was the [physical] constitution [makeup] of the victim?"). Participants' responses to those three parts of the protocol were coded as accurate memory, partially accurate memory, and non-accurate memory. The last, fourth part of the protocol covered one question about the degree of certainty in the respondent's memory accuracy for the whole incident. The degree of certainty in memory accuracy had a five-step Likert-type response format (1 – completely unsure; 2 – not sure; 3 – undecided; 4 – I'm sure; 5 – completely sure). In choosing the questions, their practical aspects were taken into account, more precisely, questions were asked that would be asked to witnesses in real circumstances of testimony. In the case of the characteristics of the perpetrators and the characteristics of the victim, questions are asked that the witnesses are usually asked in real conditions when the perpetrator of the crime is unknown.

Respondents answered the questions in the protocol and evaluated all the characteristics of both incidents separately, which lasted from 15 to 20 minutes for each incident. Respondents were asked to answer the questions as accurately as possible, and if they did not know the answer to the question, they were instructed to respond with "I do not know". Protocol scoring was conducted by one criminal psychology expert, in line with the pre-prepared scoring form. To check the validity of the first-coder response coding, the second coder scored the responses of 10% of randomly selected respondents. Cohen's kappa coefficient value was .86, which indicated a high degree of agreement between the coders.

Research Design and Data Analysis

This research applies a one-factorial design for the repeated measure. In all main analyses, the independent variable is the retention interval/delay, with four levels – T1 to T4. The dependent variable in all analyses that apply one-factorial design is confidence in memory accuracy. Dependent variable varies across different analyses, and they are described in more detail before any sections which contain results. In general, the dependent variable was the accuracy of recall, whereas the victim, perpetrator, and scene were three different characteristics for which accuracy of recall was assessed. The main analysis was conducted by applying a one-way analysis of variance for repeated measures (one-way RM ANOVA).

Additional analyses were performed by using nonparametric alternatives for RM ANOVA - Friedman ANOVA, descriptive statistics and correlation analysis. All analyses were conducted in the SPSS program (Version 25.0).

RESULTS

Memory Accuracy for Individual Incidents

Descriptive statistical parameters and correlation coefficients for memory accuracy are presented in Table 1. Skewness and kurtosis values were within the recommended ± 2 range for most continuous measures (George & Mallery, 2010). Deviations from the normal distribution are present for event characteristics (T1 and T2), second (T3 and T4) and third (T4) perpetrators of the event in the first incident, as well as event characteristics (T1, T2, and T4), the first perpetrator (T3), and the victim (T1 and T2) in the case of the second incident. Deviations of individual measures from the normal distribution were expected due to the higher degree of memory accuracy in the first measurements and the lower degree of memory accuracy in the later measurements, which are universal characteristics of memory (Wixted et al., 2018).

Table 1. *Descriptive Statistics and Correlations between Different Measurements within the Same Characteristics*

Incident	Characteristics	Measure	Min	Max	M	SD	Sk	Ku	T1	T2	T3
Participating in a fight	Event	T1	1.50	6.00	5.58	0.65	-4.67	26.26			
		T2	1.50	6.00	5.19	0.79	-1.82	5.15	-.007		
		T3	3.00	6.00	4.88	0.85	-0.68	-0.78	.251*	.475**	
		T4	3.00	6.00	5.05	0.74	-0.91	0.01	.085	.498**	.570**
	First perpetrator	T1	1.50	4.00	3.08	0.59	-0.71	-0.05			
		T2	1.00	4.00	2.60	0.66	-0.07	-0.66	.360**		
		T3	0.00	4.00	2.47	0.65	-0.37	1.02	.341**	.623**	
		T4	1.00	3.50	2.52	0.60	-0.09	-0.81	.288**	.301**	.360**
	Second perpetrator	T1	1.50	4.00	2.71	0.53	0.07	-0.57			
		T2	1.00	3.50	2.24	0.55	0.25	0.24	.163		
		T3	0.00	3.00	2.12	0.64	-1.49	3.45	.180	.449**	
		T4	0.00	3.50	2.16	0.54	-1.08	4.76	.128	.239*	.450**
	Third Perpetrator	T1	0.00	4.00	2.43	0.64	-0.35	2.43			
		T2	0.00	3.50	2.15	0.69	-0.78	1.84	.062		
		T3	0.00	3.50	2.04	0.77	-0.78	1.68	.021	.395**	
		T4	0.00	3.50	2.09	0.54	-0.62	5.03	.301**	.028	.277**
	Victim	T1	0.00	4.00	2.91	0.73	-0.59	1.80			
		T2	0.00	4.00	2.44	0.69	-0.44	0.76	.257*		
		T3	0.00	4.00	2.41	0.66	-0.61	1.02	.317**	.374**	
		T4	0.00	3.50	2.24	0.57	-0.20	2.10	.149	.249*	.511**
Robbery	Event	T1	2.00	6.00	5.33	0.57	-2.64	12.92			
		T2	2.00	6.00	5.09	0.61	-1.63	6.51	.090		
		T3	2.00	6.00	4.91	0.77	-1.21	1.53	.118	.379**	
		T4	0.00	6.00	4.78	1.04	-2.07	5.86	.139	.385**	.672**
	First perpetrator	T1	1.00	4.00	3.21	0.65	-0.74	0.71			
		T2	1.00	4.00	2.79	0.64	-0.51	0.32	.214*		
		T3	0.00	4.00	2.76	0.67	-0.83	2.24	.252*	.505**	
		T4	0.00	4.00	2.70	0.82	-1.04	1.57	.264*	.358**	.570**
	Second perpetrator	T1	1.50	4.00	2.92	0.69	0.11	-0.99			
		T2	0.00	4.00	2.55	0.74	-0.72	1.17	.106		
		T3	0.00	4.00	2.38	0.80	-0.87	1.13	.263*	.617**	
		T4	0.00	4.00	2.35	0.82	-0.84	0.69	.385**	.378**	.528**
	Victim	T1	0.00	4.00	2.59	0.63	-1.00	2.75			
		T2	0.00	4.00	2.59	0.73	-1.38	3.70	.355**		
		T3	0.00	4.00	2.53	0.89	-0.78	0.79	.398**	.645**	
		T4	0.00	4.00	2.29	1.07	-0.75	-0.44	.345**	.470**	.547**

Note. T1 – first measurement, T2 – second measurement, T3 – third measurement, T4 – fourth measurement, Min – minimum value, Max – maximum value, M – arithmetic mean, SD – standard deviation, SK – skewness, Ku – kurtosis, * $p < .01$, ** $p < .001$.

In general, the correlations between the first measurement and the remaining measurements were consistently lower than the correlations between T2, T3, and T4. The highest correlations were present between T2 and T3 as well as between T3 and T4. Correlations between the first and last measurements were of the lowest intensity and are not statistically significant in half of the cases.

To examine the effect of delay on memory accuracy, a series of analyses of variance for repeated measurements (ANOVA RM) were conducted. In each analysis, the independent variable was the factor of the delay which had four levels (T1 to T4), while the dependent variable (one in each analysis) was the accuracy of the recall for event, perpetrator and victim characteristics, separately for incident 1 and incident 2.

The main effects for each analysis are shown in Table 2. The obtained results indicate that the effects of repeated measurements were significant for all three types of characteristics in both incidents. In other words, the effect of delay on memory accuracy leads to statistically significant changes in the accuracy of memory, regardless of whether it is the characteristics of the event, the perpetrator or the victim for both incidents. To examine the magnitude of the retention accuracy, change due to retention, a partial eta squared ($ή^2_p$) was also computed. Concerning Cohen's (1988) criteria for effect size, where .01 indicates small effect, .06 medium and over .14 large effect, all effects obtained can be characterized as large, except for the effect of victim characteristics in the second incident, which is moderate.

Table 2. *The Main Effects of the Accuracy of Memory for Three Characteristics for Both Incidents Separately*

Incident	Characteristics	λ	F	DF	p	$ή^2_p$
Participating in a fight	Event	.625	17.41	3, 87	**.000**	.375
	First perpetrator	.520	26.82	3, 87	**.000**	.480
	Second perpetrator	.571	21.78	3, 87	**.000**	.429
	Third perpetrator	.792	7.60	3, 87	**.000**	.208
	Victim	.618	17.90	3, 87	**.000**	.382
Robbery	Event	.784	7.98	3, 87	**.000**	.216
	First perpetrator	.708	11.98	3, 87	**.000**	.292
	Second perpetrator	.651	15.54	3, 87	**.000**	.349
	Victim	.904	3.07	3, 87	**.032**	.096

Note. λ – value of the lambda coefficient, F – value of the F quotient, DF – number of degrees of freedom, p – p-value, $ή^2_p$ – partial eta squared.

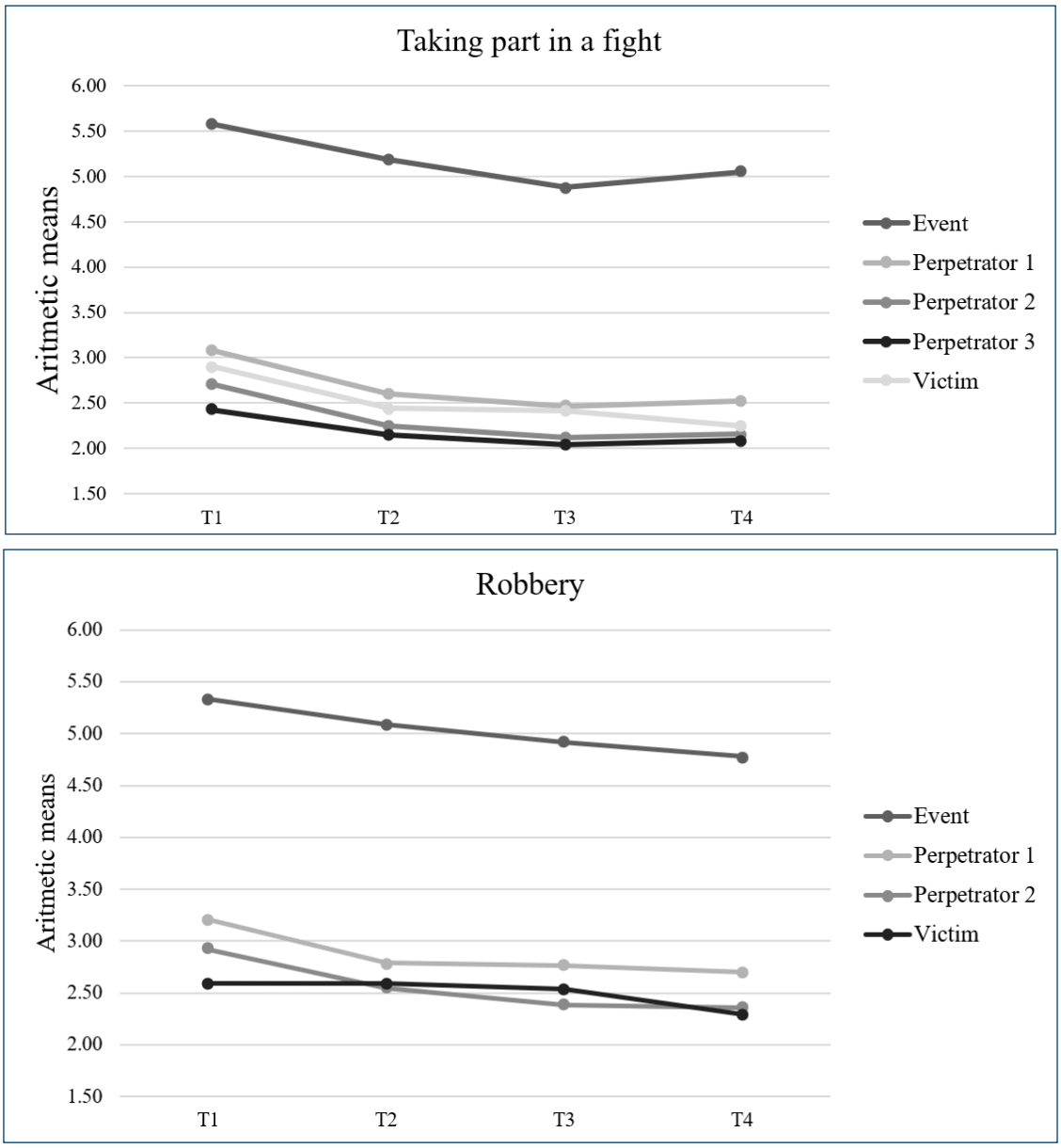
The differences between the pairs of individual measurements are presented in Table 3. For the first incident (participation in a fight), the respondents recall more accurately all characteristics in T1 in contrast to T2, T3 and T4. Respondents remember event characteristics in T4 more accurately than in T3, while victim characteristics have a greater degree of accuracy in T2 compared to T3 and T4. Concerning the second (robbery) incident, the differences were most pronounced in the victim's characteristics, with memories being more accurate in T1 concerning all three remaining measurement points, which do not differ significantly between themselves. With regard to event characteristics for the second perpetrator, all measurements differ in expected direction, i. e. memory declines with greater retention, while there was no significant difference between T3 and T4. In the case of the first perpetrator, the accuracy of memory is significantly higher in T1 compared to all the remaining intervals, which statistically do not differ significantly among themselves. A graphical representation of the results is presented in Figure 1. Given the deviations of in-

dividual measurements from the normal distribution (Table 1), the results of the ANOVA RM were further verified by applying Friedman's ANOVA. This analysis is a non-parametric replacement for the ANOVA RM and is not sensitive to data distribution. The results indicated an identical pattern of results, except for the case of victim characteristics in the second incident, which were not significantly different across measurements. Given the high degree of congruence of results obtained from these two analyses, the results obtained using the ANOVA RM were retained and interpreted as valid.

Table 3. *Post-hoc Test for the Accuracy of Memory for Three Characteristics for Both Incidents Separately*

Characteristics			Participating in a fight		Robbery	
			AS_{dif}	p	AS_{dif}	p
Event	T1	T2	.395	**.000**	.246	**.004**
	T1	T3	.700	**.000**	.421	**.000**
	T1	T4	.529	**.000**	.556	**.000**
	T2	T3	.305	**.001**	.176	**.036**
	T2	T4	.134	.104	.311	**.003**
	T3	T4	-.171	**.032**	.135	.101
First perpetrator	T1	T2	.483	**.000**	.424	**.000**
	T1	T3	.616	**.000**	.450	**.000**
	T1	T4	.561	**.000**	.511	**.000**
	T2	T3	.133	**.029**	.026	.701
	T2	T4	.078	.322	.088	.324
	T3	T4	-.055	.463	.061	.411
Second perpetrator	T1	T2	.461	**.000**	.374	**.000**
	T1	T3	.586	**.000**	.537	**.000**
	T1	T4	.546	**.000**	.568	**.000**
	T2	T3	.125	.065	.164	**.024**
	T2	T4	.085	.234	.194	**.038**
	T3	T4	-.040	.552	.031	.713
Third perpetrator	T1	T2	.276	**.005**		
	T1	T3	.393	**.000**		
	T1	T4	.342	**.000**		
	T2	T3	.117	.172		
	T2	T4	.066	.468		
	T3	T4	-.051	.551		
Victim	T1	T2	.464	**.000**	.005	.953
	T1	T3	.495	**.000**	.060	.507
	T1	T4	.663	**.000**	.301	**.007**
	T2	T3	.031	.696	.056	.451
	T2	T4	.199	**.017**	.296	**.005**
	T3	T4	.168	**.011**	.241	**.018**

Note. T1 – first measurement, T2 – second measurement, T3 – third measurement, T4 – fourth measurement, AS_{DIF} – differences between means.



Note. Higher scores on the y-axis indicate higher memory accuracy for different domains of events.

Figure 1. *Differences in Arithmetic Means between Different Characteristics of Both Incidents in Different Time Points*

Memory Accuracy for Both Incidents

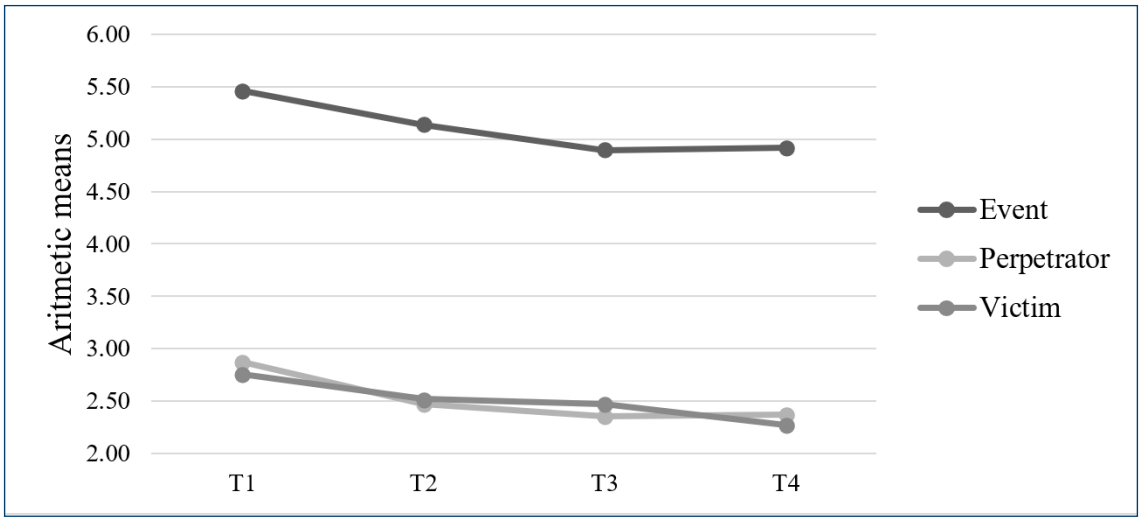
In order to examine the effect of delay on memory accuracy, regardless of the type of crime shown in the video-audio recordings, ANOVA RMs were further conducted on the merged data for both incidents, but also on the merged data for the same type of characteristics (e.g. all characteristics of all perpetrators in both incidents). The main effects indicate that retention affects the accuracy of memory in the case of each characteristic: events ($\lambda = .63$, $F\ [87/3] = 17.32$, $p < .001$, $\acute{\eta}^2_p = .374$), perpetrators ($\lambda = .42$, $F\ [87/3] = 40.35$, $p < .001$, $\acute{\eta}^2_p = .582$), and victims ($\lambda = .69$, $F\ [87/3] = 12.84$, $p < .001$, $\acute{\eta}^2_p = .307$).

The results of the post-hoc tests are shown in Table 4. When it comes to event and perpetrator characteristics, the differences are not significant only between T3 and T4, with significant differences between all remaining pairs of measurements being in the expected direction; longer retention time was followed by a lower degree of accuracy of memory. When it comes to the characteristics of the victim, the differences are not significant between T2 and T3 only, with significant differences between all remaining pairs of measurements in the expected direction (Figure 2).

Table 4. *Post-hoc Test for the Accuracy of Memory for Three Characteristics for Both Incidents*

Characteristics		Event		Perpetrators		Victim	
Measure time point		AS_{DIF}	p	AS_{DIF}	p	AS_{DIF}	p
T1	T2	.320	**.000**	.403	**.000**	.234	**.001**
T1	T3	.561	**.000**	.516	**.000**	.278	**.000**
T1	T4	.542	**.000**	.506	**.000**	.482	**.000**
T2	T3	.240	**.001**	.113	**.017**	.043	.450
T2	T4	.222	**.005**	.102	**.086**	.248	**.001**
T3	T4	-.018	.754	-.011	.826	.204	**.002**

Note. T1 – first measurement, T2 – second measurement, T3 – third measurement, T4 – fourth measurement, AS_{DIF} – differences between means.



Note. Higher scores on the y-axis indicate higher memory accuracy for different domains of events.

Figure 2. *Differences in Arithmetic Means between Different Characteristics for Both Incidents in Different Time Points*

Descriptive statistics and correlation coefficients for the estimated confidence in memory accuracy for each incident separately are presented in Table 5. Skewness and kurtosis values were within the acceptable range (± 2) for all measurements in both incidents. The correlations of confidence in memory accuracy for each incident separately were all statistically significant, positive, and of moderate intensity. It is noticeable that the correlations between T2, T3, and T4 are consistently higher than the correlation of T1 with the remaining measurement intervals.

Table 5. *Descriptive Statistics and Correlations between Different Measurements for Confidence in Memory Accuracy for Each Incident Separately*

Incident	Measure	M	Min	Max	SD	Sk	Ku	T1	T2	T3
Participating in a fight	T1	3.29	1.00	4.00	0.83	-.719	-.794			
	T2	2.54	1.00	5.00	0.89	.648	-.375	.316**		
	T3	2.41	1.00	4.00	0.91	.516	-.560	.371**	.501**	
	T4	2.25	1.00	4.00	0.91	.696	-.193	.237*	.419**	.494**
Robbery	T1	3.54	1.00	5.00	0.87	-1.088	.614			
	T2	2.73	1.00	4.00	0.91	.101	-1.080	.384**		
	T3	2.49	1.00	4.00	0.93	.406	-.817	.336**	.559**	
	T4	2.40	1.00	5.00	0.99	.510	-.514	.371**	.558**	.459**

Note. T1 – first measurement, T2 – second measurement, T3 – third measurement, T4 – fourth measurement, Min – minimum value, Max – maximum value, M – arithmetic mean, SD – standard deviation, Sk – skewness, Ku – kurtosis, * $p < .01$, ** $p < .001$.

To examine differences in the degree of confidence in memory accuracy as a function of time-flow for each incident separately, two analyses of variance for repeated measurements were applied. When it comes to the first incident, the main effect was significant ($\lambda = .47$, $F(83/3) = 30.97$, $p < .001$, $ή2p = .528$), indicating that certainty in memory accuracy changes significantly over time, and the effect of these differences were large. When it comes to individual measurements, differences were not present only in the case of comparisons of T2 and T3 ($AS_{DIF} = .105$, $p = .259$). Significant differences were present in the comparison of all remaining pairs of measurements, with higher scores (higher degree of certainty) being consistently present in measurements that were chronologically earlier within the pair being compared.

For the second incident, the main effect was significant ($\lambda = .41$, $F(83/3) = 39.69$, $p < .001$, $ή^2_p = .589$), indicating that confidence in the memory accuracy changes significantly with time, and the effect of these differences was large. When it comes to individual measurements, the difference was not present only in the case of comparisons of T3 and T4 ($AS_{dif} = .151$, $p = .145$). Significant differences were present in the comparison of all remaining pairs of measurements, with a higher degree of confidence consistently present in measurements that were chronologically earlier within the pair being compared (Figure 3).

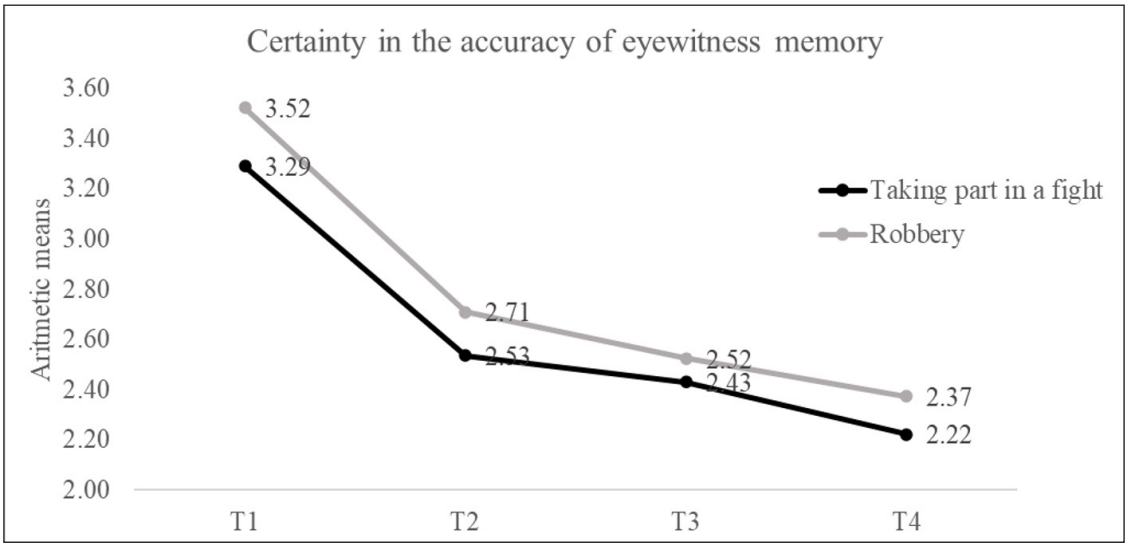


Figure 3. *Differences in Arithmetic Means for Both Incidents Separately in the Context of the Certainty in the Accuracy of Eyewitness Memory*

The Relationship between Memory Accuracy and Confidence in Memory Accuracy

The correlation between memory accuracy and confidence in the memory accuracy for all characteristics of both incidents together is presented in Table 6. The correlations between accuracy and confidence in memory accuracy were statistically significant, positive and low to moderate in all four measurements. The values of correlation coefficients range from .240 to .317.

Table 6. *Relationships of Memory Accuracy and Confidence in Memory Accuracy for Both Incidents Together*

Variables	Correlation
Memory accuracy x confidence in memory accuracy (T1)	.240*
Memory accuracy x confidence in memory accuracy (T2)	.266*
Memory accuracy x confidence in memory accuracy (T3)	.317**
Memory accuracy x confidence in memory accuracy (T4)	.248*

Note. * $p < .05$, ** $p < .01$.

DISCUSSION AND CONCLUSION

The main conclusion of this research was that a high degree of memory accuracy is present immediately after watching the video-audio recording, but also that such accuracy falls after one month and after three months, whereby the effect of the decline in memory accuracy is big in terms of effect size. Differences in memory accuracy three and six months after viewing the recording are predominantly significant, but are of lower intensity. The

achieved results agree with the results of a series of previous studies (Pansky, 2012; Pansky et al., 2011; Pansky & Nemets, 2012; Shapira & Pansky, 2019). In the context of two opposing groups of studies (Shapira & Pansky, 2019), the results obtained support the group of studies indicating lower memory accuracy, especially regarding the passing of time and a somewhat longer retention interval (for example, Koriat et al., 2001; Larsson et al., 2003).

The second important result of this research relates to the level of decline in memory accuracy after one month. The vast majority of conducted analyses suggest that memory accuracy after three and after six months has a very similar intensity, and that the decline in memory accuracy is not drastic, even when statistically significant differences between the two intervals are present between these two intervals. The results obtained, that is, the function of the decline in accurate memory in the context of the retention interval has certain similarities to Ebbinghaus's (1895/1964) forgetting curve. It is important to point out that no complete agreement with the forgetting curve was expected, due to the longer retention intervals applied in this research.

With regard to the different characteristics of incidents, victims, and perpetrators, the results obtained point towards a conclusion that there is no correlation between memory and these different characteristics. In other words, the functions for the decline in memory precision are very similar for characteristically different events, victims, and perpetrators, through various incidents. As far as the authors of this study are aware, these are the first findings supporting this conclusion, and they need to be replicated. On the other hand, functions for the fall in memory precision are also very similar for two different criminal acts, both when the criminal acts are examined separately, and when they are examined together. These results indicate that memory does not interact with the characteristics of different crimes. The message for future research would be a replication of the obtained results in the context of criminal acts comprising extremely violent elements. The assumption is that extremely emotional contents might play a mediating role among memory precision, the retention interval, and the characteristics of the criminal act.

In conclusion, the results of this research clearly indicate that memory precision falls drastically after one month, and continues to decline after three months, but after that the further decline is minimal over the period of six months. The resulting pattern of results is almost identical for different types of criminal offence, and for different characteristics of criminal acts. The results completely support the conclusion of Roediger and DeSota (2014) that memories are relatively unstable and that representations of memory are partial and static. At the same time, this result could imply that eyewitnesses may be observed "critically" as sources of information (Wells et al., 2006), because their memories are not only potentially unreliable, but also inherently unreliable (Wixted et al., 2018). This may also imply that the witness should be heard as soon as possible, as well as that the credibility of their testimony must be checked in terms of agreement with other results of the evidentiary proceedings. On the other hand, it is important to note that simulated testimony was used in this research, so it is necessary to examine the ecological validity of the obtained results, which is a guideline for future research.

With regard to certainty in memory precision, the obtained results indicate very similar patterns to those of memory precision per se. Certainty in memory precision decreases drastically after the first measurement, while after that there is a marked moderate decline in subsequent measurements. On the other hand, there is a noticeable difference in

the magnitude of effects for these two phenomena. In other words, certainty in memory precision declines more over time than memory precision per se. A possible explanation for these differences is the manner in which these two phenomena are measured. Memory precision can be observed objectively, whereas certainty in memory precision is measured subjectively, which cannot be measured by objective methods. Additionally, the assumption is that certainty in memory precision is characterized to a great extent by the individual psychological characteristics of respondents, in contrast to memory precision per se which is primarily shaped by biological and physiological instances. The finding of a significant correlation between memory accuracy and certainty in memory accuracy agrees with the results of previous studies (Odinot & Wolters, 2006; Wixted & Wells, 2017). The above relations are of low to moderate intensity, and of little effect. A result that stands out in particular is the lowest degree of correlation of these two phenomena at the first measurement, contrary to the expectation that at the first measurement these two measurements would be associated to the highest degree. The effects obtained could possibly be explained in several ways. It is possible that results obtained are due to the different nature of measures and etiological factors that shaped them, which was discussed previously. The other potential explanation and, at the same time, limitation of this study is the way in which certainty in memory precision was measured. In this research, respondents evaluated their certainty in memory accuracy only once for each measurement on a general level, i. e. for the incident as a whole. The lesson for further research would be to use more detailed measures of certainty in memory accuracy. On the other hand, it is possible that these two phenomena are not tightly connected, at least in the sample covered by this research. On the one hand, the capacity and functioning of memory among strong young individuals is relatively uniform, while on the other hand this need not be the case with the degree of certainty in memory accuracy. In other words, it is possible that range restrictions occur due to similar functioning of the respondents' memory.

LIMITATIONS AND GUIDELINES FOR FURTHER RESEARCH

With regard to the retention interval, the advantage of this research is that it used intervals similar to time intervals in the case of testifying in real conditions, especially in criminal proceedings. The potential limitation of research is the insufficiently tested ecological validity of results obtained on student samples, in contrast to real eyewitnesses. Earlier studies had indicated that young respondents from the general population differ in relation to the functioning of memory units compared to particularly sensitive eyewitnesses, such as children and older individuals (Koren et al., 2006; Pansky et al., 2009; Roebers & Schneider, 2005). The third limitation relates to other factors that might influence memory reliability, for example, heightened emotions (Areh, 2004), which are not covered in this research. The fourth limitation mentioned above related to the method of measuring the degree of certainty in memory accuracy, which was measured on a general level for the whole incident, and not for each answer individually.

PRACTICAL APPLICATION

The results obtained have strong implications for police and judicial/court practice regarding the examination of witnesses and they confirm the large corpus of earlier research on this theme.

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REFERENCES

Areh, I. (2004). Pričanja očividcev – dejavniki, ki vplivajo na verodostojnost priče. *Revija za kriminalistiko in kriminologijo*, *55*(3), 275–284.

Baić, V., & Deljkić, I. (2019). *Kriminalistička psihologija*. Fakultet za kriminalistiku, kriminologiju i sigurnosne studije.

Blackwell-Young, J. (2008). Witness evidence. In G. Davies, C. Hollin, & R. Bull (Eds.), *Forensic psychology* (pp. 209–233). John Wiley & Sons Ltd.

Bornstein, B. H., Deffenbacher, K. A., Penrod, S. D., & McGorty, E. K. (2012). Effects of exposure time and cognitive operations on facial identification accuracy: A meta-analysis of two variables associated with initial memory strength. *Psychology, Crime and Law*, *18*(5), 473–490. https://doi.org/10.1080/1068316X.2010.508458.

Penrod, S., & Cutler, B. (1995). Witness confidence and witness accuracy: Assessing their forensic relation. *Psychology, Public Policy, and Law*, *1*(4), 817–845. https://doi.org/10.1037/1076-8971.1.4.817

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Routledge.

Deffenbacher, K. A., Bornstein, B. H., Penrod, S. D., & McGorty, E. K. (2004). A meta-analytic review of the effects of high stress on eyewitness memory. *Law and Human Behavior*, *28*(6), 687–706. https://psycnet.apa.org/doi/10.1007/s10979-004-0565-x

Ebbinghaus, H. E. (1895). *Memory: A contribution to experimental psychology*. Dover (Republished 1964).

Evans, J. R., & Fisher, R. P. (2011). Eyewitness memory: Balancing the accuracy, precision and quantity of information through metacognitive monitoring and control. *Applied Cognitive Psychology*, *25*(3), 501–508. https://doi.org/10.1002/acp.1722

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/bf03193146

Garrett, B. (2011). *Convicting the Innocent.* Harvard University Press.

George, D., & Mallery, M. (2010). *SPSS for Windows step by step: A simple guide and reference, 17.0 update* (10th ed.) Pearson.

Gustafsson, P. U., Lindholm, T., & Jönsson, F. U. (2019). Predicting accuracy in eyewitness testimonies with memory retrieval effort and confidence. *Frontiers in Psychology*, *10*, 703. https://doi.org/10.3389/fpsyg.2019.00703

Howitt, D. (2009). *Forensic and criminal psychology.* Pearson Education.

Ibabe, I., & Sporer, S. L. (2004). How you ask is what you get: On the influence of question form on accuracy and confidence. *Applied Cognitive Psychology*, *18*(6), 711–726. http://dx.doi.org/10.1002/acp.1025

Innocence project. (2018). *Innocence Project*. https://www.innocenceproject.org/

Ivanović, Z., & Baić, V. (2019). *Taktika obezbeđivanja* iskaza. Kriminalističko-policijski univerzitet.

Koren, D., Seidman, L. J., Goldsmith, M., & Harvey, P. D. (2006). Real-world cognitive--and metacognitive--dysfunction in schizophrenia: A new approach for measuring (and remediating) more "right stuff". *Schizophrenia Bulletin*, *32*(2), 310–326. https://doi.org/10.1093/schbul/sbj035

Koriat, A., Goldsmith, M., & Pansky, A. (2000). Toward psychology of memory accuracy. *Annual Review of Psychology*, *51*, 481–537. https://doi.org/10.1146/annurev.psych.51.1.481

Koriat, A., Goldsmith, M., Schneider, W., & Nakash-Dura, M. (2001). The credibility of children's testimony: Can children control the accuracy of their memory reports? *Journal of Experimental Child Psychology*, *79*(4), 405–437. https://doi.org/10.1006/jecp.2000.2612

Krafka, C., & Penrod, S. (1985). Reinstatement of context in a field experiment on eyewitness identification. *Journal of Personality and Social Psychology*, *49*(1), 58–69. https://doi.org/10.1037/0022-3514.49.1.58

Larsson, A. S., Granhag, P. A., & Spjut, E. (2003). Children's recall and the cognitive interview: Do the positive effects hold over time? *Applied Cognitive Psychology*, *17*(2), 203–214. https://doi.org/10.1002/acp.863

Lindholm, T., Jönsson, F. U., & Liuzza, M. T. (2018). Retrieval effort cues predict eyewitness accuracy. *Journal of Experimental Psychology Applied*, *24*(4), 534–542. https://doi.org/10.1037/xap0000175

Loftus, E. F. (1975). Leading questions and the eyewitness report. *Cognitive psychology*, *7*(4), 560-572. https://doi.org/10.1016/0010-0285(75)90023-7

Loftus, E. F. (2003). Make-believe memories. *American Psychologist*, *58*(11), 864–873. https://psycnet.apa.org/doi/10.1037/0003-066X.58.11.867

Malpass, R. S., & Devine, P. G. (1981). Guided memory in eyewitness identification. *Journal of Applied Psychology*, *66*(3), 343–350. https://doi.org/10.1037/0021-9010.66.3.343

Morgan, C. A., Southwick, S., Steffian, G., Hazlett, G. A., & Loftus, E. F. (2013). Misinformation can influence memory for recently experienced, highly stressful events. *International Journal of Law and Psychiatry*, *36*(1), 11-7. https://doi.org/10.1016/j.ijlp.2012.11.002

Odinot, G., & Wolters, G. (2006). Repeated recall, retention interval and the accuracy–confidence relation in eyewitness memory. *Applied Cognitive Psychology*, *20*(7), 973–985. https://psycnet.apa.org/doi/10.1002/acp.1263

Pansky, A. (2012). Inoculation against forgetting: Advantages of immediate versus delayed initial testing due to superior verbatim accessibility. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(6), 1792–1800. http://dx.doi.org/10.1037/a0028460

Pansky, A., Goldsmith, M., Koriat, A., & Pearlman-Avnion, S. (2009). Memory accuracy in old age: Cognitive, metacognitive, and neurocognitive determinants. *European Journal of Cognitive Psychology*, *21*(2–3), 303–329. https://doi.org/10.1080/09541440802281183

Pansky, A., & Nemets, E. (2012). Enhancing the quantity and accuracy of eyewitness memory via initial memory testing. *Journal of Applied Research in Memory and Cognition*, *1*(1), 2–11. https://doi.org/10.1016/j.jarmac.2011.06.001

Pansky, A., Tenenboim, E., & Bar, S. K. (2011). The misinformation effect revisited: Interactions between spontaneous memory processes and misleading suggestions. *Journal of Memory and Language*, *64*(3), 270–287. http://dx.doi.org/10.1016/j.jml.2010.12.003

Pozzulo, J. D., & Warren, K. L. (2003). Descriptions and identification of strangers by youth and adult eyewitnesses. *Journal of Applied Psychology*, *88*(2), 315–323. https://psycnet.apa.org/doi/10.1037/0021-9010.88.2.315

Roediger, H. L. III, & DeSoto, K. A. (2014). Understanding the relation between confidence and accuracy in reports from memory. In D. S. Lindsay, C. M. Kelley, A. P. Yonelinas, & H. L. Roediger II (Eds.), *Remembering: Attributions, processes, and control in Human Memory: Essays in Honor of Larry Jacoby* (pp. 347–367). Psychology Press.

Roebers, C. M., & Schneider, W. (2005). The strategic regulation of children's memory performance and suggestibility. *Journal of Experimental Child Psychology*, *91*(1), 24–44. https://doi.org/10.1016/j.jecp.2005.01.001

Sarwar, F., Allwood, C. M., & Innes-Ker, Å. (2014). Effects of different types of forensic information on eyewitness' memory and confidence accuracy. *The European Journal of Psychology Applied to Legal Context*, *6*(1), 17–27. https://www.elsevier.es/en-revista-the-european-journal-psychology-applied-381-articulo-effects-different-types-forensic-information-S1889186114700083

Scheck, B., Neufeld, P., & Dwyer, J. (2000). *Actual innocence: Five days to execution, and other dispatches from the wrongly convicted.* Doubleday.

Shapira, A. A., & Pansky, A. (2019). Cognitive and metacognitive determinants of eyewitness memory accuracy over time. *Metacognition and Learning*, *14*(3), 437–461. https://doi.org/10.1007/s11409-019-09206-7

Vrij, A., Fisher, R. P., & Blank, H. (2017). A cognitive approach to lie detection: A meta-analysis. *Legal and Criminological Psychology*, *22*(1), 1–21. https://doi.org/10.1111/lcrp.12088

Wells, G. L., Memon, A., & Penrod, S. D. (2006). Eyewitness evidence: Improving its probative value. *Psychological Science in the Public Interest*, *7*(2), 45–75. https://doi.org/10.1111%2Fj.1529-1006.2006.00027.x

Wise, R. A., & Safer, M. A. (2004). What US judges know and believe about eyewitness testimony. *Applied Cognitive Psychology*, *18*(4), 427–443. https://doi.org/10.1002/acp.993

Wixted, J. T., Mickes, L., & Fisher, R. P. (2018). Rethinking the reliability of eyewitness memory. *Perspectives on Psychological Science*, *13*(3), 324–335. https://doi.org/10.1177%2F1745691617734878

Wixted, J. T., & Wells, G. L. (2017). The relationship between eyewitness confidence and identification accuracy: A new synthesis. *Psychological Science in the Public Interest*, *18*(1), 10–65. https://doi.org/10.1177%2F1529100616686966