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Pursuit Driver Training Improves Memory for Skill-Based Information

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Police drivers must attend to information from multiple sensory modalities during a high-speed pursuit. This aises an important question: Does training facilitate the shifting of focus between visual and auditory modalities and the subsequent recall of information? The authors tested personnel from the London Metropolitan Police Service to see if various levels of driving training influenced memory recall during an attention-shifting task. Participants were presented standard and police-related memory items while simultaneously attending to distracters. Brain activity was measured to the presentation of the distracters to ensure participants are indeed paying attention to both tasks. The authors found that training did have a significant effect on memory for police-related items. The results are attributed to training because the experimental design ruled out concentration and natural ability as possible explanations.

Keywords: *training; pursuit driving; memory; attention; multitasking*

The human attentional system has an amazing ability to process information from different sources and from different sensory modalities simultaneously. This capacity is often termed *cross-modal attention*. Cognitive neuroscientists and researchers in related fields are beginning to understand and emphasize the importance of cross-modal attentional processes in everyday life (Eimer, 2001). In fact, it has been argued that by not studying attentional processes cross-modally, it is improbable that we can develop an accurate model of how attention is processed in the brain (Driver & Spence, 1998; Spence & Driver, 1997; Spence, Nicholls, Gillespie, & Driver, 1998).

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In other words, if the functional aspects of attention are studied and defined in each sensory system independently, the synergistic effect of how attention is used in everyday life will be lost. A common example of this is how we engage in conversation in a noisy room. To understand what another person is saying, we generally combine visual cues—such as lip reading—with auditory information. In this way, attention is given to both visual and auditory signals that are then meshed together by our brain in a fashion that increases our chances of understanding what has been said.

Another feature of our attentional system is its capability to focus resources and pay special attention to a particular event or object. Rather than a normal conversation in a noisy room, consider how the brain processes incoming information when concentration levels are high. When a person is intently watching a sporting event on television, for example, the person will generally be inattentive to a conversation taking place right next to him or her, even if the television volume is muted and the conversation is rather loud. This focusing of attention toward a particular source of interest seems to preclude the processing of other information from the environment, as if sensory signals are in some way weighted by the attentional system, where intense attentional focus changes the weighted values of the sensory inputs. But does this focusing of attention truly result in a change in the ratio of weighted inputs from the different sensory modalities in the brain? Research has shown that in fact it does (Shomstein & Yantis, 2004), and additionally, that higher order cognitive processes actually work to suppress input from the unattended sensory systems. Presumably, this acts to direct as much of the available cognitive resources as possible to the attended task.

That focusing attention on only one thing results in the suppression of other information in the environment raises a critical question: What if the "other" environmental information is in some way important? In other words, if a person is engaged in a task that requires intense focus and the result of this intense focus is that some environmental information is suppressed, what if the suppressed information is important or even necessary to properly address the situation? In a case such as this, information essential to a task may go unprocessed with the added problem that it may therefore be unavailable for subsequent recall. This attentional biasing has also been an object of study (Hopf, Schoenfeld, & Heinze, 2005; Hopfinger, Buonocore, & Mangun, 2000; Hopfinger, Woldorff, Fletcher, & Mangun, 2001), generally by requiring participants to attend to more than one item while measuring performance on a related task. One type of attentional biasing that directly relates to the current research is measuring reaction times of drivers while talking on mobile/cellular phones. Specifically, research has shown that focusing attention on a cell phone conversation results in slower reaction times to visual objects appearing on the road in a simulated driving task (Strayer & Drews, 2004; Strayer, Drews, & Johnston, 2003).

What does this mean for professionals where cross-modal processing may be essential to their job? Law enforcement is such a profession. Officers are expected—even required, to the extent that a cognitive process can be required—to pay attention to all details in their environment so that later they can give an accurate accounting of these details as well as the order in which they occurred. But what if an officer is intensely focused on only one item in the environment, like a threatening suspect or a get-away car? Scientific research suggests, as presented above, that "other" information within the environment is at the least disadvantage, and may even go unnoticed (to see how focused concentration affects something as simple as visual perception, see Simons & Chabris, 1999). In fact, research suggests that in situations involving danger or threat, stress-related cognitive interference competes for brain resources, resulting in even larger decrements in attentional resources available to process environmental information (Garavan, 1998; McElree, 2001; Sliwinski, Smyth, Hofer, & Stawski, 2006; Verhaeghen & Basak, 2005). Now, in addition to intense concentration, stress-related processing is also robbing attentional resources. It is no wonder there are so many anecdotal reports of police officers not seeing another suspect arriving on the scene or not hearing a partner who is screaming in their ear.[1] For officers involved in these types of situations, will additional training facilitate their ability to process the "other" in their environment?

There are numerous ways to approach studying the effects of training on skill-based memory. In the current research project, we designed a laboratory study to try to understand how memory is affected by cross-modal shifts of attention. More specifically, we wanted to see if training resulted in better multitasking skills and consequently better memory recall of skill-based information. We chose to measure multitasking and memory for the skill of driving and thus recruited officers with specific driving qualifications from the London Metropolitan Police Service (MPS). Driving training was selected for two reasons: (a) multitasking skills are paramount when pursuing another vehicle at high speeds and thus allow for a systematic analysis of driving training and memory and (b) the MPS has distinct levels of driving training with some of the highest training standards in the world. These two reasons are described in more detail below.

a. Stating that multitasking skills are necessary while driving is, at the least, stating the obvious. But multitasking skills are even more imperative for police drivers because they are required to pay close visual attention to the environment they are maneuvering their vehicles through—often at very high speeds—while at the same time monitoring other sensory sensations from the police band on their radio, their partner, the steering wheel, and the vehicle in general. As mentioned above, research has shown that focusing attention in one modality results in the suppression of information from other modalities, which suggests that for pursuit drivers engaged in a chase situation, both auditory and tactile information will not be well attended to (and visual information will not be completely attended to), or attentional resources will have to be directed back and forth between what the driver is seeing and what is heard and felt.
b. The two metropolitan police training qualifications we included in this study are *response driver* and *pursuit driver*. The MPS has standardized driver training courses at the Hendon driving school and several satellite schools in the London

area that train officers in driver safety. One of the offered courses is a 2-week response driver-training course that instructs drivers how to respond to police-related emergency calls by driving fast but safely to an emergency. A follow-up course—for those wanting advanced training—is a 4-week pursuit driver course. In this training course, officers are instructed how best to pursue suspects fleeing in a vehicle. This is a more rigorous course because now drivers are not only driving fast but they are also engaged with another vehicle. One of the focuses of this advanced course is learning to control the driving environment around the pursuit vehicle. In other words, learning how best to influence traffic and pedestrians that are in the path of the pursuit by using specific driving behaviors.

Method

Participants

Twenty-one MPS employees were recruited for this study. Seven participants held a valid driver's license but had not received any formal police-driving training, 7 were trained response drivers, and 7 were trained pursuit drivers. Of the police-trained drivers, some held other driving qualifications—for example, some drivers were also trained motorcycle drivers—but for our purposes, we categorized all police-trained officers as either response or pursuit drivers based on the particular qualification held. The research was conducted at Centrex at Bramshill, Hampshire and the Hendon driving school. All gave written informed consent to participate that met both Minnesota State University and metropolitan police ethical standards. In addition to departmental hearing and vision screenings, each participant was screened for discrimination of the three audio tones and three colored circles used in this study as distracting stimuli (stimulus details are given below).

Memory Stimuli

Each participant was presented a series of standard and police-related memory items through a Dell Latitude D600 laptop computer. Standard memory items consisted of 100 simple sketched drawings (such as an eagle, a balloon, a harp, and so on) and 100 spoken words (such as "snake," "airplane," "grapes," and so on recorded by a British speaker) taken from the Snodgrass and Vanderwart (1980) series of common objects. Police-related items consisted of videos of actual police pursuits in the London area recorded by Provida cameras mounted in the police cars and actual police radio transmissions (all police-related stimuli were provided by MPS).

Distracter Stimuli

Visual and auditory distracter stimuli were presented alone and concurrent with the cross-modal memory stimuli (i.e., visual distracters were paired with auditory memory stimuli and auditory distracters were paired with visual memory stimuli). Visual distracters were black (RGB = h000000), blue (RGB = h0000FF), and green (RGB = h00FF00) circles created using the Microsoft Paint program and subtended a visual angle ≈5.5°. Auditory distracters were low (1,000 Hz), medium (1,800 Hz), and high (2,000 Hz) tones created using the Stim[2] NeuroScan stimulation software package (Compumedics USA, El Paso, Texas).

Electrophysiological Measure

The electroencephalograph (EEG) measured how well participants were attending to the distracters. This was accomplished using the *recognition response,* is a physiological measure used to objectively quantify attention. To use this technique, researchers present a series of standard stimuli (like a "beep") interspersed with a few target stimuli (a beep of a different pitch) and record brain activity related to the two sounds. If a participant realizes the beeps are different, one area of the brain—an area at the top and back of the head that is considered to be an important part of the loop that makes up the attentional system in the brain—responds differently to the rare presentations than it does to the frequent. This area, located at cortical site P_z, is thought to be the gatekeeper of the cortical attentional system because irrelevant sensory input is suppressed at this site during concentration. Responses to the target beep are evident at this site by a large positive deflection in the response waveform about one third of a second after presentation of the target. However, if the participant is not paying attention to the two different sounds, there is no consistent difference in the way this area of the brain responds to these sounds, which is why this measure is tied to recognition. In other words, a person has to be paying attention to the sounds for the brain to respond differently to the target stimuli. If a person is only paying attention to a small degree, there will be a small positive deflection in the waveform. Measuring the size of the response—or the amplitude—indicates to what extent a person was attending to the task.

Each participant was fitted with a 40-electrode nylon cap (Compumedics Quik-Cap with Ag/AgCl electrodes, El Paso, Texas, USA) and connected to a NeuroScan NuAmps Express portable EEG system (Compumedics model 7181). The QuikCell electrolyte application system (Compumedics) was used for electrode/scalp connections and impedances were kept below 10 kΩ at all electrode sites. Recording was continuous at 1,000 Hz and was stored on a Dell Latitude D810 portable computer. Continuous recordings were filtered and epoched offline at 1,100 ms (100 ms prestimulus; 1,000 ms poststimulus).

Measures of Memory

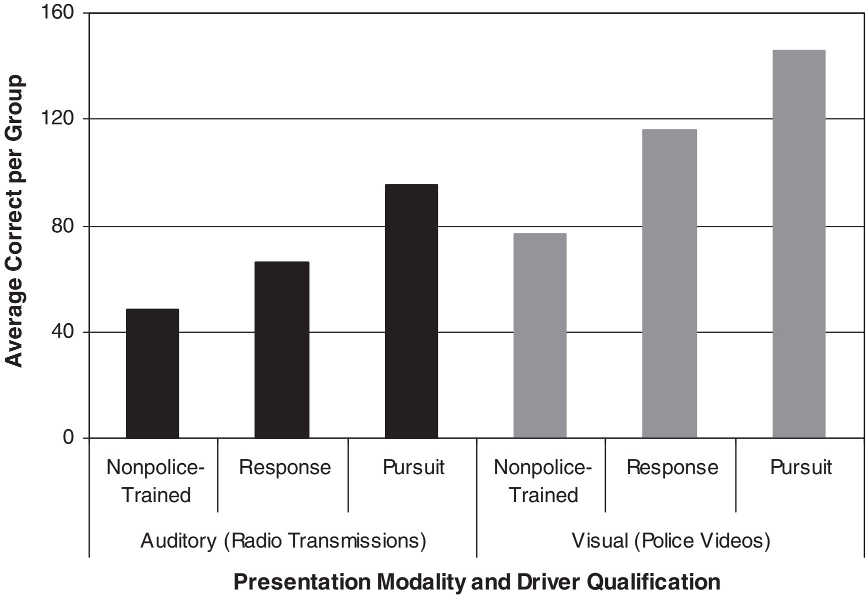
Memory performance was assessed for standard items (words and pictures) and training-related items (police driving videos and police radio transmissions). For standard items, each participant was shown five sets of 20 pictures and listened to five sets of 20 recorded words. At the end of each set, participants were asked to write down as many items as they could remember. Correct responses in each set were counted and a memory score for standard items was assigned to each participant. Participants were also shown five video clips, each lasting approximately 1 min, and listened to five 1-min audio recordings of police radio transmissions. These were the training-related memory items. At the end of each video and audio recording, participants were asked to verbally report as much about the events presented to them as they could remember, in as much detail as possible. They were also asked to report the events in the same order as they occurred. It was stressed to the participants that their verbal recalls could include any information; they were not limited to a certain type of information. These verbal reports were recorded to a file on a computer hard drive using a microphone and later transcribed for scoring purposes. The transcriptions were broken down into propositions that were then scored for accuracy. An inaccurate proposition was assigned a score of 0; a proposition that was true but was general in nature was assigned a score of 1 (e.g., "the driver passed a motorcycle"); and a true proposition that contained detailed information was given a score of 2 (e.g., "the motorcycle driver was wearing a red crash helmet"). Scores were then tallied for each audio and video recording and an overall score was assigned to each participant for the training-related memory items.

Procedures

Participants first read and signed a consent form to participate and were fitted with a nylon electrode cap and connected to the EEG. They were then presented with the memory items. The order the items were presented in was randomized so that about half of the participants were shown the visual memory items first (within this group, half were shown the pictures first, half were shown the police videos first); the others listened to the auditory memory items before seeing the pictures and videos (this was also randomized so that about half listened to the spoken words first, the others listened to the police radio transmissions first). This precaution was taken so that practice would not bias one type of presentation or sensory modality over the other.

Concurrent with participants watching and listening to these memory items, brain activity was recorded to the distracting beeps and circles. For the visual memory items, participants were instructed to pay special attention to the videos and pictures because their memory for these items would later be tested, while covertly counting the number of high tones sounded. They were further instructed to ignore the low and medium tones. During auditory presentations, participants were instructed to listen very closely to the words and radio transmissions because their memory would be assessed on those items, while simultaneously and covertly counting the number of blue circles presented on a computer screen. Each participant was instructed to ignore

Figure 1
Group Scores for Police-Related Memory Items



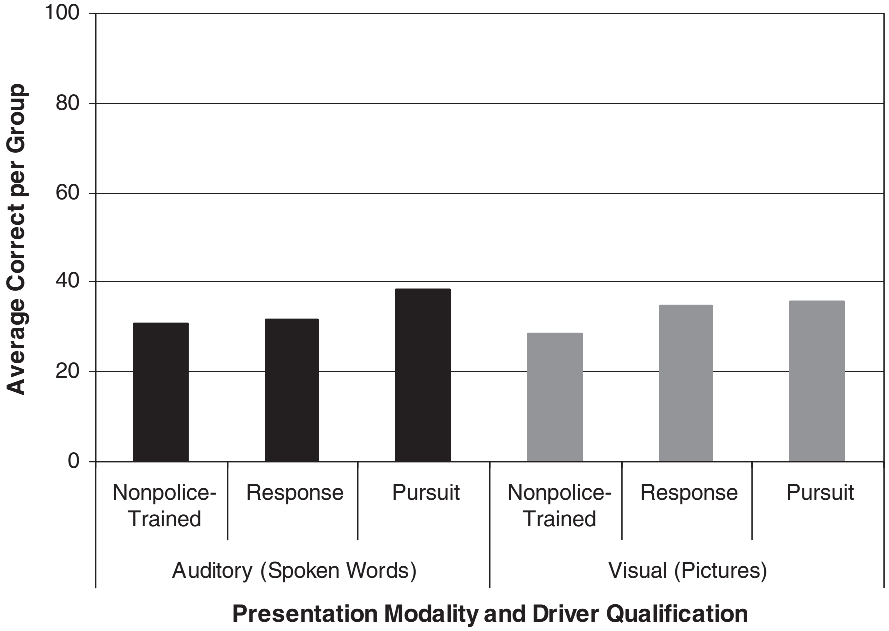
Note: On the left side of the graph are group scores for memory of radio transmissions (black bars); on the right are scores for police videos (gray bars). Statistical analyses determined there was a significant effect of training and presentation modality. See text for details of group comparisons.

the black and green circles. These dual tasks required participants to shift their attention back and forth cross-modally between vision and audition. There was also a “distracter only” condition for the beeps and circles that preceded each memory condition so that baseline brain activity could be recorded and later compared with cross-modal performance.

Results

Memory for standard and police-related items was compared across the three training qualifications (nonpolice-trained drivers, response drivers, and pursuit drivers). A 3 × 2 Training × Presentation Modality analysis of variance showed significant effects for both training ($F = 4.87$, $p = .020$) and presentation modality ($F = 17.05$, $p = .001$) for police-related items. Comparisons of group performances showed there was a significant effect of training on memory of police videos between nonpolice-trained drivers and pursuit drivers ($F = 5.49$, $p = .031$). There was also a significant

Figure 2
Group Scores for Standard Memory Items



Note: On the left side of the graph are scores for standard memory items presented auditorily (black bars); on the right are scores for pictures presented visually (gray bars). No significant effects of training or of presentation modality were found. Additional analyses determined there were no significant differences in any of the group performances.

effect of training on memory of radio transmissions between nonpolice-trained drivers and pursuit drivers (F = 14.26, p = .001) and response drivers and pursuit drivers (F = 5.55, p = .030). Although there was a trend for increasingly higher memory scores across training qualifications (see Figure 1), none of the other group comparisons reached significance.

For standard memory items, an analysis of variance found no significant main effects for either training or presentation modality. Additional analyses were performed to compare groups in each condition: No statistical differences between groups were found in any treatment combination (see Figure 2 for graph of group performances in each condition).

In addition to memory data, electrophysiological data were collected. Brain activity was analyzed for differences in cortical responses to the target and standard distracting stimuli. A large difference suggests the participant was devoting a large amount of attention to the distracter task; little to no difference suggests the participant was paying

Table 1
Ratios of the Difference in Target and Standard Responses

	Ratio of Difference		
Conditions	Nonpolice-Trained Drivers	Response Drivers	Pursuit Drivers
CO (%)	72.6	59.1	72.6
CW (%)	55.7	58.0	58.7
CR (%)	57.0	55.2	59.5
TO (%)	62.1	74.7	71.6
TP (%)	55.0	60.2	57.1
TV (%)	55.2	59.2	58.6

Note: A table of the ratio of differences between brain responses to standard and target stimuli. Ratios were determined by dividing the target stimuli amplitude by the combined amplitudes of target and standard responses ($T_A / (T_A + S_A)$) of the distracting circles and tones. This function determines the size of the target amplitude in relation to the standard amplitude. Labels are as follows: the first letter refers to the distracter (C = colored circles, T = tones), the second letter refers to the memory condition (O = distracter only, W = spoken words, R = radio transmissions, P = pictures, and V = police videos). Ratios are largest for conditions where only the distracter was presented (CO and TO).

little attention, if any, to the distracters. Differences that fall in-between suggest the participant was paying some attention to the distracters, but was not paying full attention. Because there are large individual differences in amplitude signals, we calculated a ratio of the difference between brain responses to standard and target stimuli.[2] With this method, a low percentage infers little attention was given to the distracters; a high percentage suggests a large amount of attention was paid to the distracters. As can be seen in Table 1, more attention was given to conditions where the distracter was presented alone (CO and TO conditions, see table legend for label details) than when presented concurrent with the memory items. Ratios for the recognition response to standard and police-related memory items show participants were giving less attention to the distracters during these conditions but were paying about the same amount of attention for each (again, see Table 1).

Discussion

The purpose of this study was to assess the impact of training on skill-based memory. By designing a laboratory study where variables could be tightly controlled, we were able to dissociate skill-based memory (police-related items in this instance) from normal memory processes under conditions where multitasking was required. Multitasking was a variable we chose to use because it better resembles what police drivers actually do on the job. It has also been argued that attentional processes can be better understood when observing them cross-modally (Driver & Spence, 1998;

Spence et al., 1998; Spence, Nicholls, & Driver, 2001). By recruiting participants with various levels of police driving training, we found that more training resulted in better memory for the police-related items.

Just because participants with more training scored better on skill-based memory tests does not necessarily mean the differences are a result of training. There are at least two other reasons that may explain why the pursuit drivers scored higher on average than the response drivers and the drivers who had no police-driver training: (a) the pursuit drivers may be naturally more intelligent with better and more efficient memory systems than participants with lesser training qualifications, which may explain why they were selected to train at the highest level in the first place; and/or (b) better scores for pursuit drivers may be the result of them devoting more attention to the video and radio transmission stimuli than the other participants, meaning they completely ignored the distracters and concentrated fully on the memory task, whereas the other participants attended to the distracters only or attended to both tasks.

Our experimental design allowed us to assess both of these options. By testing each groups' memory for standard (nonpolice related) items, the superior memory performance of the pursuit drivers disappeared (compare Figures 1 and 2). In fact, there was no significant difference between any of the groups' memory performances for spoken words or pictures from a standardized set of objects. This result argues that the memory systems of the pursuit drivers are probably not naturally superior to those with lesser driving qualifications.

The second possible interpretation was tested by comparing recognition responses to the distracting stimuli. By comparing the ratio of the amplitude differences between standard and target stimuli, we found that all three groups showed a similar pattern of concentration. Each group had much higher amplitude ratios when the only task was to attend to the distracters, meaning they were giving full or nearly full attention to covertly counting the number of blue circles or high tones presented by the computer. This finding was expected because attending to the distracters was the only task required in this condition. When attending to the distracters while also observing the memory stimuli, all groups showed a marked reduction in the ratios of amplitude differences. This means that the groups were now shifting attention cross-modally between the memory task and the distracters, which resulted in less overall attention being given to the distracters. Importantly—at least for testing the plausibility of the second possible explanation—all groups seem to have given about the same amount of attention to the memory tasks. In other words, no group stands out as having given all their attention to the memory stimuli or all their attention to the distracters as evident by the fairly systematic change in ratios for these conditions (see Table 1 for group performance comparisons).

This leaves us with our default assumption—differences in skill-based memory scores are because of differences in training, with more training resulting in better memory. The design of the current study does not allow for an understanding of how training results in better skill-based memory, but we can make some inferences based on the methods of training. For example, one of the requirements of metropolitan police pursuit drivers during training is that they give a verbal commentary of their cognitive processes while driving. This task serves several purposes, one of which is to allow the instructor to assess the thought processes leading up to driving decisions and performance. In this way, the metropolitan police driving school implements a model of "training with correction." It is not good enough that a driver initiates and completes a task correctly—the driving instructor wants to make sure the student initiated and performed the task for the right reasons. Giving a verbal commentary allows the instructor to assess intent. We believe that by learning to give a running commentary while driving, instructors are shaping a perspective of how pursuit drivers should view driving scenarios, a perspective that more than likely becomes automated.[3] If this is the case, then whether they are driving a vehicle, riding as a passenger, or simply viewing a video of a drive, pursuit drivers may initiate an internal dialog commenting on the drive as it progresses. This is a reinforcing behavior that may aid in subsequent memory recall. Our data do not contradict this assumption: Although there was a trend, there was no significant difference in skill-based memory scores between nonpolice-trained drivers and response drivers. The largest differences were between the pursuit drivers and the drivers with lesser qualifications.

We believe these findings are a significant first step in understanding how training can influence memory recall for police pursuit drivers. A specific area of interest that was highlighted with this study, but that was not directly tested, relates to the course curriculum and methods used in pursuit driver training. We believe a more in-depth analysis of verbal commentary during driving training should be undertaken. If it is found that this type of training method improves performance and memory of the task, it may be good to apply a similar technique to other areas of law enforcement as well.

Notes

1. Author William Lewinski has interviewed hundreds of officers who have reported these and similar attentional blunders when in danger or under conditions of real or perceived threat.

2. Amplitudes are subject to a variety of extraneous variables, such as skull thickness, gender, electrode placement on the scalp, and the amount of salt/electrolytes in one's diet, to name a few. However, determining how different each individual's standard and target responses are as a percentage controls for the above-mentioned variables. Additionally, finding a ratio of the difference allows for a meaningful comparison across participants and, more importantly for the current study, across groups.

3. The suggestion that verbal commentary becomes automated with training is an idea the pursuit drivers agreed with during informal exit interviews. In fact, those who were asked about this reported that commentary eventually becomes like a "tape recorder in the head" that starts to play when they attend to the driving process, even if they are not the actual driver. Those asked also agreed that something similar to this happened while observing the pursuit videos used in this study; they found themselves observing the videos as if they were driving the car. Thus, their observations were guided—in a way—by internal verbalization (although most said it was not of the same quality because they were also counting tones).

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