European Commission, Horizon 2020

D7.4 SHOTPROS Final Evidence-based HF Model for DMA-SR

SHOTPROS

Deliverable	D7.4
Deliverable Lead	VUA
Related work package	WP7
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Dissemination level	PUBLIC
Due submission date	30.09.2022
Actual submission	30.09.2022
Project number	833672
Instrument	RIA
Start date of project	01.05.2019
Duration	42 months
Version log	V1.0

Versions

Vers.	Date	Author	Description
V0.1	22/07/2022	Matthijs Koedijk (VUA) Vana Hutter (VUA) Alexander Schäfer (NRW) Ortwin Maetzing (NRW)	First Draft Structure
V0.2	17/08/2022	Matthijs Koedijk (VUA) Vana Hutter (VUA) Alexander Schäfer (NRW) Ortwin Maetzing (NRW)	First Draft Content
V0.3	24/08/2022	Raoul Oudejans (VUA)	Feedback & Additions
V0.4	25/08/2022	Lisanne Kleygrewe (VUA)	Feedback & Additions
V0.5	30/08/2022	Matthijs Koedijk (VUA)	Incorporating feedback and preparing version for consortium check.
V0.6	05/09/2022	Birgit Harthum (USE)	Review & Feedback
V0.7	20/09/2022	Matthijs Koedijk (VUA) Vana Hutter (VUA)	Incorporating feedback from consortium
V1.0	30/09/2022	Valerie Schlagenhaufen (USE) Gerhard Helletzgruber (USE)	Final formatting and upload

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List of Acronyms and Abbreviations

Acronym / Abbreviation	
DMA	Decision-Making and Acting
DMA-SR	Decision-Making and Acting under Stress and in High-Risk Situations
HF	Human Factors
LEA	Law Enforcement Agencies
VR	Virtual Reality

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1 Executive Summary

The Evidence-Based Human Factors Model for **Decision-making and Acting in Stressful, High-Risk Situations** (HF model for **DMA-SR**) builds the **basis** of the **SHOTPROS training framework and the SHOTPROS Virtual Reality (VR) solution**. The HF model for DMA-SR is outlined in full in deliverable D3.2 and is publicly available at https://shotpros.eu/elements-structure-of-wps/.

In the current deliverable D7.4, we present the further validation of the HF model for DMA-SR. As described in D3.2, large parts of the model have already been validated in the scientific literature. The model is genuinely evidence-based. Still, within the SHOTPROS Field Trials (see D7.1, D7.2), several model elements are further investigated to provide input for VR development and training and test the efficacy of the proposed implications (user experience) of the model for VR training. We provide conclusions on the usability and credibility of the model's implications for VR training:

- VR training is useful for manipulating all components of the stress response in VR training to suit training needs.
- VR training allows trainees to practice strategies to mitigate the adverse effects of stress and maintain acceptable performance standards.
- VR training provides trainees with unique opportunities to discover and imprint the correct decisions and actions.

In cooperation with the SHOTPROS partner North Rhine-Westphalia Police Force (LAFP NRW) and other law enforcement agencies (LEAs), **four key messages** from the model were selected to be **essential in developing a VR solution** to train police officers in their decision-making and acting performance in stressful, high-risk situations:

- The VR system should allow **natural ways of perceiving, moving,** and **processing** information for officers.
- The VR system includes **human factors that are known to be stressful** or indicate risk.
- In the VR system, attentional processes should be challenged or **challenging** (task-relevant as well as task-irrelevant (and potentially distracting) information is present).
- The VR system allows trainees **to choose between multiple decisions/actions**.

LAFP NRW and other LEAs share how they incorporate or would include each key message in their VR-training. In addition, the VR technology partner (RE-liON) describes how each key

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message is incorporated into the current system and which wishes (i.e., not yet implemented features) remain.

Ultimately, the HF model for DMA-SR provides a basis for efficacious VR training of police officers' decision-making and acting in stressful, high-risk situations. The model has consequences for both the hardware required (e.g., ability to move naturally and thus learn to use ecologically valid sensory information, provide realistic action opportunities), as well as software like scenario content used by LEAs (e.g., accurate perceptual cues, evoked stress responses).

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2 Added Value

2.1 Relation to SHOTPROS Work Packages (WPs)

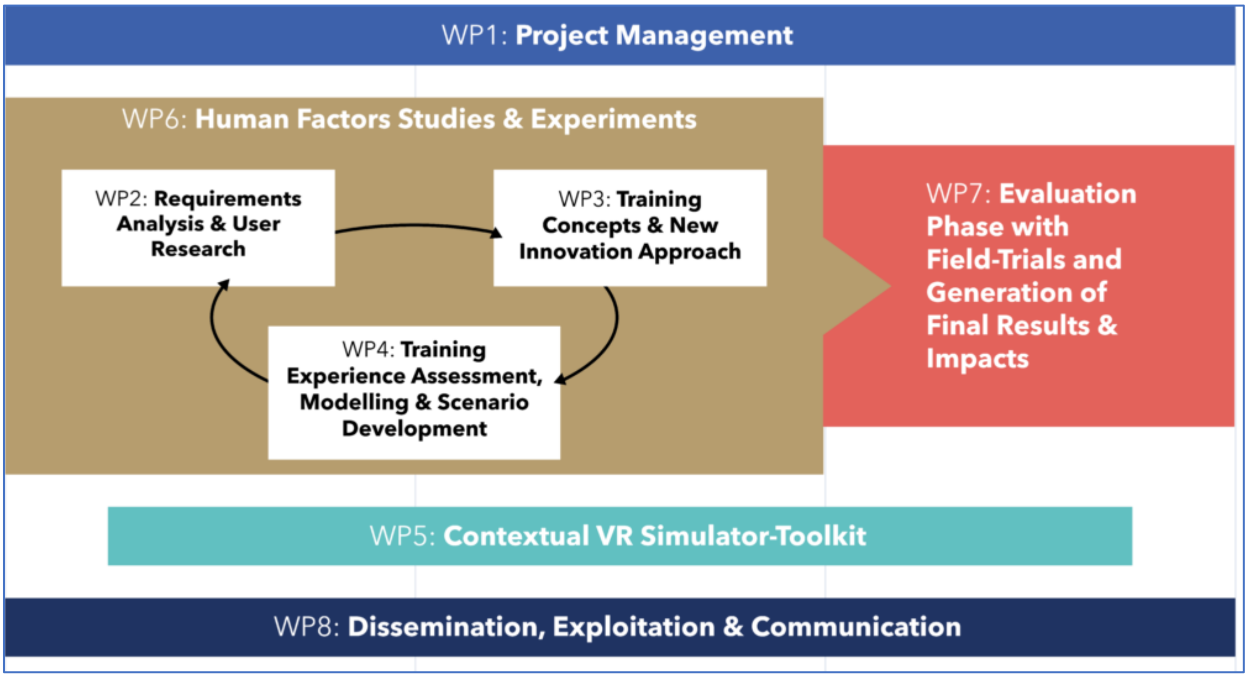

Figure 1. SHOTPROS workplan

Deliverable D7.4 is part of WP7, which covers the final evaluation and validation of the SHOTPROS VR training environment and the training framework and guidelines (see Figure 1). This deliverable comprises the validation of the HF model for DMA-SR outlined in D3.2.

2.2 D7.4 is informed by:

Deliverable	How did these deliverables influence D7.4
D3.2	Implications and user experiences of various elements of the HF model for DMA-SR outlined in D3.2 are presented in D7.4.
D7.1	The further evaluation and final validation of the training approaches in the SHOTPROS field trials, planned in D7.1, directly impacted D7.4, the HF model for DMA-SR.
D7.2	The final results of the focus groups and interviews with end users carried out during the FTs have led to a scientifically validated HF model for DMA-SR (D7.4).

Table 1. Influence of SHOTPROS deliverables on D7.4.

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2.3 D7.4 consequently feeds into:

Deliverable	How does D7.4 influence other Deliverables within SHOTPROS
D7.5	The final training framework presented in D7.5 is strongly affiliated with the HF model for DMA-SR in D7.4. The model emphasizes action as the focus of training, which forms the basis for the didactical concepts presented in D7.5
D7.6	The HF model for DMA-SR presented in D7.4 points to hardware requirements (e.g., graphics, animations, movement) for the technical guidelines of the SHOTPROS VR solution outlined in D7.6
D8.5	The policy-maker toolkit gives an overview on the most important SHOTPROS results which also includes the final HF model for DMA-SR described in D7.4.

Table 2. Influence of D7.4 on SHOTPROS deliverables.

For a clear overview on the final SHOTPROS deliverables regarding the SHOTPROS solution, the following overview is available in all introduction chapters of the regarding deliverable. Here it is visible which final deliverables influence the SHOTPROS VR solution and where to find which information:

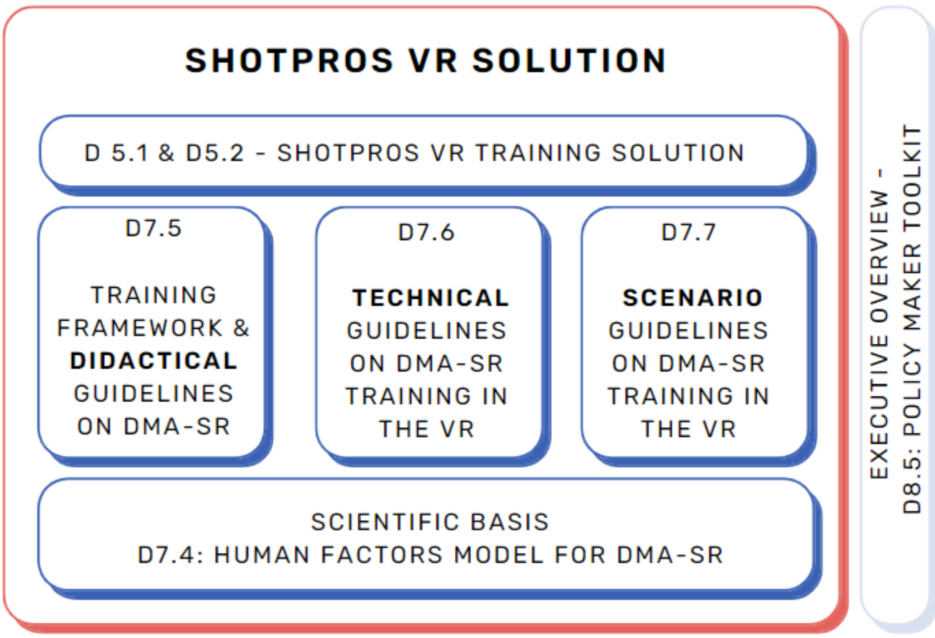

Figure 2. SHOTPROS final deliverables regarding the VR solution

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2.4 SHOTPROS Objectives Relation

Deliverable 7.4 – SHOTPROS Final Evidence-based HF Model for DMA-SR– directly contributes to SHOTPROS objective 1 ''validated HF model" by providing a validated HF model for DMA-SR that informs VR training *(see Figure 2)*. The model is the foundation for objectives 2, 3 and 4 as it dictates both technical requirements and content requirements to create efficacious VR training of decision making and acting of police officers. For example, the model results in hardware requirements (e.g., ability to move naturally and thus learn to use ecologically valid sensory information, provide realistic action opportunities), as well as scenario content demands for LEAs (e.g., accurate perceptual cues, evoked stress responses). Furthermore, the training framework & curriculum (objective 3) is strongly affiliated with HF model for DMA-SR. The model emphasizes action as the focus of training, which aligns well with the didactical criteria, based on insights for motor learning (see D7.5). Additionally, the factsheet for LEAs that is generated from the HF model for DMA-SR, is an important knowledge source for all members in the European VR network and thus also feed objective 5.

The compact factsheet targeted at LEAs, can be downloaded at the VR and Police Network site: https://vrandpolice.eu/wp-content/uploads/2021/09/SHOTPROS_DMA-model-factsheet-short.pdf and in a more detailed version at the SHOTPROS project website: https://shotpros.eu/wp-content/uploads/2021/09/SHOTPROS-Factsheet-D3.3-didactical-guidelines.pdf.

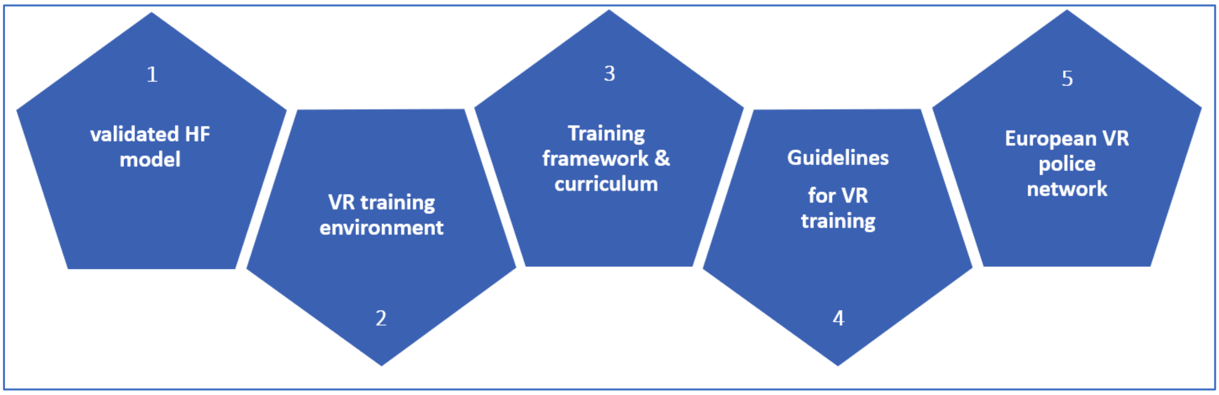

Figure 3. SHOTPROS objectives – overview

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2.5 Impact for LEAs

D7.4 impacts European LEAs in the following ways:

- By accessible key messages from the HF model for DMA-SR to create efficacious training of decision-making and acting of police officers.
- By providing a shared language and shared understanding for developers, LEAs and researchers when talking about training under stress;

2.6 Impact on the security in the EU

D7.4 strongly supports the internal security strategy for the European Union (cf. Guideline VIII - A Commitment to innovation and training) in the following ways:

- Through increasing alertness on effective concepts to advance the training of decision-making and acting of police officers in stressful situations;
- Through harmonizing the DMA-SR training for all European police forces.

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3 The Evidence-Based Human Factors Model of Police Officer's Decision-making and Acting in Stressful, High-Risk Situations

The Evidence-based Human Factors Model for Decision-making and Acting in Stressful, High-Risk Situations (HF model for DMA-SR) is the basis of the SHOTPROS training framework and the SHOTPROS VR solution. The HF model for DMA-SR is outlined in full in deliverable D3.2 and is publicly available at https://shotpros.eu/elements-structure-of-wps/.

Being a first responder in high-risk situations creates high levels of acute stress. To be prepared to deal with these stress levels on duty, it is important for police officers to receive suitable scenario-based trainings. The model depicts the impact of stress on DMA and consequently how police officers can train to enhance their DMA in real life. Stress in the SHOTPROS context is the **individual emotional response** of a police officer in a high-risk situation. People experience stress if a situation is appraised as threatening to their well-being and they perceive limitations in control or in the ability to cope with it. The perceived demands of the situation outweigh the perceived capabilities to handle the situation. How you perceive the situation (both its demands and capabilities), is influenced by different human factors. Human factors can be **personal**, **contextual**, **organisational**, or **societal**.

When stress occurs in police officers and they fail to mitigate stress responses, attentional changes occur. Officers start focusing on task-irrelevant input instead of the task-relevant input, they are inclined to interpret the situation as threatening, and their action tendencies become threat-biased as well. This leads to suboptimal DMA.

For SHOTPROS, this model forms the basis of VR training – the human factors help to create realistic VR-training where different situations and variations are provided for the trainees. Through this, police officers can train to restore or retain their attentional processes in any stressful situation and **learn to remain focused on the task-relevant inputs** and have proper interpretation and goal-directed action tendencies, and thus quality DMA.

In VR, you can manipulate the training context with just a few clicks. If VR training can be individualised for each trainee, DMA training will be optimally differentiated, which will **lead to better and more correct decisions** in real life. Importantly, the aim of the training does not necessarily have to be to make police officers less stressed or prepare them for all possibly occurring situations, but it enables them to focus on task-relevant input despite being

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stressed, instead of being distracted by task-irrelevant matters, consequently changing interpretation and action tendencies.

Figure 3 shows a graphical representation of the HF model for DMA-SR. The model can be characterized as an **input-throughput-output model**. The inputs of the model are the human factors that determine whether a situation is potentially stressful and high risk. The throughput of the model are the responses to the potentially stressful situation, specifically the occurrence of a stress response, the mental effort invested, and potential changes in attentional control as a result of the stress response and the mental effort combined. The changes in attentional control determine changes in the output: decision-making and acting, in the model specified as motor heuristics and embodied choices. For a full and more detailed description of the different parts of HF model for DMA-SR, we refer the reader to Deliverable D3.2.

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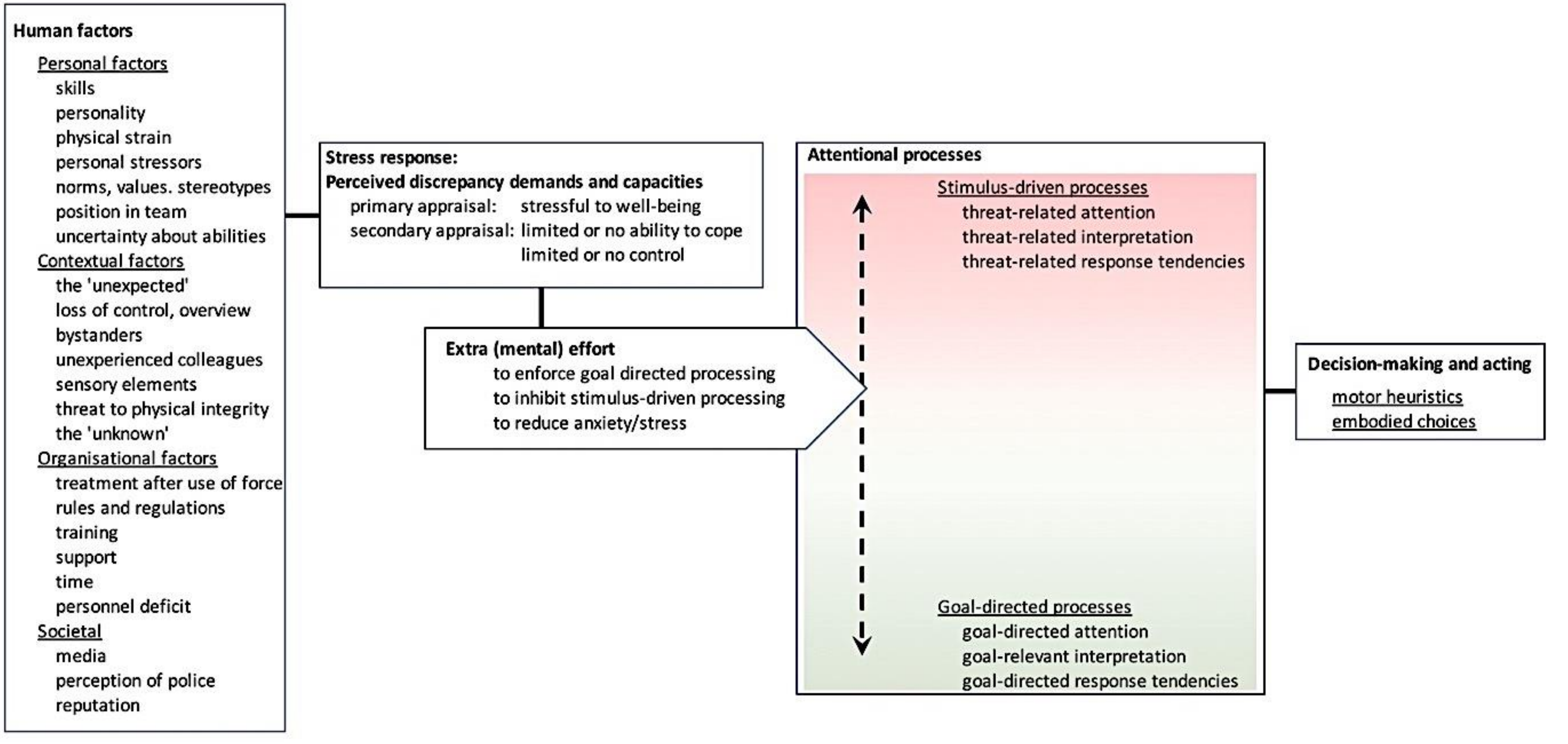

Figure 3: The Evidence-Based Human Factors Model of Police Officer's Decision-making and Acting in Stressful, High-Risk Situation

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4 Scientific Validation of the HF model for DMA-SR

Within SHOTPROS, several elements of the model were further investigated to provide input for development of VR training, and to test the efficacy of the proposed implications (user experience) of the model for VR training. The Vrije Universiteit Amsterdam (VUA) evaluated police officers' and trainers' experience with the VR training during the field trials (D7.1, D7.2) conducting post-training focus groups. The Ruprecht-Karls-Universität Heidelberg (UHEI) explored the links between trainees' attention and subsequent decision-making and acting processes (DMA) through short, semi-structured qualitative interviews.

4.1 Validation of the Model with focus Groups

During the field trials, VUA conducted **seven focus groups with a total of 22 police officers and trainers** (hereafter called 'trainees'), held after their training as part of the SHOTPROS field trials. VUA selected three core tenets of the HF model for DMA-SR and its implications for VR training to further evaluate in the field trials:

1. **Cognitive and sensory information**: can trainees in VR perceive both cognitive and sensory information in a natural way?
2. **Stress mitigation**: does the VR training provoke stress and allow trainees to train in mitigating attentional processes?
3. **Task-relevant and irrelevant information**: does the VR training allow trainees to practice with both task-relevant and task-irrelevant information?

Three different focus group protocols were used, one for each of these three tenets. Each focus group started with **a brief introduction video** to explain the part of the model that would be discussed with the officers. The videos are available in English, German, Dutch and Romanian and links to the videos are provided with the results presented below.

4.1.1 Can trainees in VR perceive both cognitive and sensory information in a natural way?

VR training should enable trainees to use both cognitive and sensory information, meaning that trainees can perceive, move and process information in a natural/realistic way in VR. Cognitive information refers to the thoughts, knowledge and memories that trainees can cognitively recall, such as judicial frame for use of force or a safe distance to maintain from a suspect with a knife. Sensory information refers to anything the trainees perceive through their senses, such as the speed at which they move or a perceived threat affecting their

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alertness and stress level. Explanation videos on cognitive and sensory information can be found on:

English: https://video.vu.nl/media/FGcognitive+sensory_english/1_9h3n0j8e
German: https://video.vu.nl/media/FGcognitive+sensory_german/1_n3igzkjw
Romanian: https://video.vu.nl/media/FGcognitive+sensory_romanian/1_4wgdpya1
Dutch: https://video.vu.nl/media/FGcognitive+sensory+dutch/1_7w2xhxx9

Results:
The trainees claimed that although they had to get used to the environment (*what am I wearing and what can I do in the VR?*), the novelty of **VR did not distract them from cognitively retrieving information and making decisions and acting as they normally would**:

> *"Procedures were easy to practice and not very different from real-life. Walking behind each other and clearing the building came very close to what we do in real-life training."*

> *"I was able to use the usual mechanisms, had the same focus and goals."*

> *"The goals mentioned by the trainer were very clear, which helped with the realism of my thoughts."*

In addition to the positive feedback about the use of cognitive information in the VR scenarios, the trainees indicated that the VR system also allowed them **to feel sensory input in a natural way**. The trainees stated that moving around in the environment felt realistic and that they experienced a level of alertness and stress that they normally experience in real life:

> *"I liked the fact that the corridor was narrow, this felt very natural. You also get a good idea of the spatial environment. For example, how far apart the doors are"*

> *"Movement felt realistic, and the gear felt like 90% my daily gear"*

> *"The VR environment does mimic a real situation well. If someone comes to me with a knife, I do have that 'oh help'-feeling."*

A number of trainees indicated that they had more difficulty to recall cognitive information in a natural way. They stated that they were distracted and therefore did not fully immerse themselves in the VR scenario:

> *"I didn't find it very realistic myself. I was mainly concerned with not getting sick."*

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"The space under my eyes (of the VR glasses) was distracting, 1 colleague had very colourful shoes (in real life) that distracted me."

Next to being distracted, the trainees referred to aspects of the VR technology that influenced their *usual* decision-making and acting. The points mainly had to do with the design and objects in the environment, the interaction with people, and the use of resources:

"The rooms are rectangular and clean. An average Amsterdam home is very different. Many more blind spots. Now the rooms were very easy to overlook, and I am less inclined to check them out" .

"Taking cover in VR feels less naturally than in real-life. In real-life there is a real cover (object or wall). In VR, you are only pretending that you are behind a wall".

"This is because you don't see emotion. You can't see if someone is scared, angry or aggressive. Normally you can see whether a person wants to cooperate."

"You apply a different weapon technique because you focus on the red dot instead of the grain. That is not ok to train"

"Fingers cannot move. If you have something in your hands, it looks rather clumsy in the environment. It is also less easy to see what the suspect is doing with his hands"

The trainees share a sense of curiosity about how VR technology will develop in the future and made clear wishes and suggestions on how to improve sensory and cognitive information in the VR system:

"It is important that we can see each other well and that the distances between us are correct and that we can hold on to each other. This is more important than anything else in the environment."

"More haptic feedback, for example a pain stimulus really does something to your experience"

"The stress of making the right choice is important to add, do I go left or right? Moments that you have to choose in a split second should be included"

"Increase the complexity, more blind spots, messy rooms, small spaces, elements you can run into."

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> *"What I found difficult is that everyone has the same face. You cannot see who is who. That is important for the division of roles. Maybe you can alternate the hair colours of the avatars. That way, with relatively small things, you can make it feel real"*

> *"It would be great if there were objects in the room that you could actually touch, objects that you could place, and move away for a moment makes it more realistic. But also think of footstep sounds, door sounds, the sound of a door handle"*

In conclusion, **most trainees** indicated that they **could perceive, move, and process information in a quite natural way** and in close resemblance to real life. However, trainees experienced problems that prevented them from fully engaging with the scenarios. Trainees indicated that this was due to distraction or motion sickness, but also because they had to **adapt their usual thinking and actions** due to the technological limitations of the VR system, such as the inability to physically grasp objects and the limited facial expressions of the opponents/avatars, whereas the latter is already approached by the additional experimental SHOTPROS environment based on the more detailed Unreal graphic environment. The trainees gave a few (relatively) easy-to-implement suggestions to improve the sensory and cognitive information, such as adding more complexity to the spaces and making them less rectangular, adding more haptic feedback (such as a pain stimulus – which was then used in the experimental environment with positive feedback), and adding more variety to the appearance of the avatars of both the opponents and the trainees themselves (also see the features of the experimental environment and D7.6).

4.1.2 Does the VR training allow trainees to train in mitigating attentional processes?

Stress should be provoked in VR training (Trainer Dashboard (see D4.5), role-players, and scenario design), and the VR training should allow for practicing mitigation strategies as proposed by the model: i.e., restoring or maintaining goal-directed attention and thus action despite elevated stress levels. Therefore, the VR scenarios in training should include factors that induce stress and several elements of task-relevant information (e.g., weapons) and task-irrelevant information (e.g., a loud TV) that may draw attention. As such, VR training can facilitate trainees to train their attentional processes and subsequent actions while immersed in a stressful scenario. The explanation videos on mitigation of attentional processes can be found on:

English: https://video.vu.nl/media/FGmitigation_english/1_7i0lv4bq
German: https://video.vu.nl/media/FGmitigation_german.mp4/1_f0y82gx6

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Romanian: https://video.vu.nl/media/FGmitigation_romanian/1_dnm34xjk
Dutch: https://video.vu.nl/media/FGmitigation_dutch/1_acxpwaox

Results:
When we asked trainees to mention factors that induced stress in the VR training scenarios, they listed numerous examples:

> *"We saw blood and put our hand on our gear immediately"*

> *"We had to work around bystanders/hostage"*

> *"I didn't have experience with a flashbang, so I thought I was killed"*

> *"The suspect suddenly appeared behind the bystanders"*

The trainees' stress response may shift their attention to task-irrelevant stimuli, rather than being guided by their personal goals, such as handcuffing the suspect or keeping the suspect calm. More specifically, the trainee is more easily distracted, and it becomes more difficult to redirect attention. When we asked the trainees if they were able to stay focused on information that was relevant to the task at hand, the answers were strongly dependent on the (personal) stress levels they experienced during the VR scenarios. For the less complex scenarios during the VR training, (which were typically used as entrance training scenarios and then followed by medium and high stress level scenarios), about one-third of trainees mentioned that these scenarios did not provoke enough stress to distract them, in which case there was no need (and no opportunity to practice) to restore or maintain their attentional processes. One of the trainees illustrated this with:

> *"It was an empty, clean room, there were not a lot of people, no danger, so nothing to raise our focus"*

When the scenarios became more complex, most trainees reported experiencing stress. Trainees now reported that their attention was sometimes being "hijacked" by stimuli that were not relevant to the task. Moreover, participants tended to interpret the stimuli as threatening:

> *"The flashbang, where did this come from? I thought I was going to die"*

> *"We only saw the persons on the floor, I thought there was also a suspect among these people"*

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Consequently, the trainees reported that it became more difficult for them to keep or shift their attention to other, possibly more relevant, stimuli:

“The effort was okay, until the flashbang happened, I froze for a couple of seconds, so if the suspect could have done something there”

“We didn’t see the gun on the car”

Although the trainees had more difficulty concentrating on task-relevant stimuli when the complexity of the scenarios increased and the number of stressful factors increased (e.g., the flashbang), the overall impression among trainees was that they were still able to maintain acceptable performance standards; thus, successfully applying and practicing attentional mitigation strategies under stress (i.e., restoring or maintaining their goal-directed attention and thus action):

“My effort was not very high, because we are trained for this. We were also with two police officers, so my colleagues took the hostages aside so I could focus on the suspect”

“The situation could be controlled piece by piece; we could stay very focused despite all the small spaces”

“The initial information given by the trainer put me in a lower state of mind, because I know from experiences how to deal with gasoline”

The trainees we interviewed seem to thoroughly enjoy practicing with their attention under stressful circumstances. They stated that VR is a useful tool to practice mitigation strategies.

“It’s nice that you can vary in location in VR, you continuoulsy have to adapt to the circumstances and unexpected things, it keeps you focused”

“Why? Police officers don’t really know to make the difference, they expect orders and just execute these orders. With this tool, they can learn to think for themselves, to make the decisions themselves”

“First, you need to have the skills, then you need to know the tactics, and with this tool you can practice and develop your “police mindset”

Although the stress experienced by the trainees was highly personal and situational, most trainees we interviewed concluded that the **VR scenarios included factors that induce stress,**

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facilitating them to practise their attentional processes and subsequent actions under stress. The trainees stated that they were able to counteract some of the destructive effects of stress and thus maintain more or less accurate levels of decision-making and action despite experiencing stress. Trainees stated that VR training could be particularly useful for practising mitigation strategies, as it allows for efficient and rapid manipulation of locations and the presence or absence of certain stressors.

4.1.3 Does the VR training allow trainees to practice with task-relevant information and task-irrelevant information?

In addition to factors that induce stress, **VR training scenario should include both elements** of **task-relevant** information (e.g., weapons) and **task-irrelevant** information (e.g., a loud TV) that may draw attention. In this way, trainees are able to practice focusing on the task-relevant stimuli. The explanation videos on task relevant and task irrelevant information can be found on:

English: https://video.vu.nl/media/FGgoalrelevantstimuli_english/1_qithg8ov
German: https://video.vu.nl/media/FGgoalrelevantstimuli_german/1_759ngvsa
Romanian: https://video.vu.nl/media/FGgoalrelevantstimuli_romanian/1_zl5bcswj
Dutch: https://video.vu.nl/media/FGgoalrelevantstimuli_dutch/1_3xxzuy59

Results:
We asked trainees about both task-relevant stimuli and task-irrelevant stimuli they observed during the VR training scenarios. Trainees described different task-relevant stimuli they focused on in the VR training scenarios:

> *"I scan for weapons held by the suspect, for example a broken bottle or a lighter"*
>
> *"For me an important indicator of the situation is the lack of response by suspect"*
>
> *"I pay attention to the movement of a suspect"*
>
> *"We noticed the small spaces to maneuver, that is consequential for the team formation"*

In contrast to the considerable amount of task-relevant information that the trainees mentioned, they indicated that the **distracting information was limited**. Therefore, the trainees suggested to include more aspects in the VR scenarios that would make it harder not to be distracted. This could **further stimulate the trainees' practice in redirecting their attention to task-relevant stimuli**, despite stressful conditions (see also 4.1.2, *does the VR*

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training allow the trainees to train in mitigating attentional processes?). Trainees mentioned several aspects that can increase distraction in VR scenarios:

> *"Placing people in a blind spot"*
>
> *"By bystanders, in some scenarios it was now an empty building. Make it cluttered"*
>
> *"I'm thinking of moving images, cat walking past, shadows, mirrors, tv reflecting on something"*
>
> *"Crossroads, many more roads to take and to focus"*
>
> *"A table, for example. This is a handicap. How do you go around it when you have to call a suspect?"*
>
> *"Noise from bystanders, people shouting for help.*

When we critically asked the trainees whether goal-oriented attention in the presence of task-irrelevant stimuli could not also be practised perfectly in a real-life training house, one of the trainees refuted this suggestion by describing:

> *"No, that is not possible. The training possibilities are limited. Normally you already know the building. In VR, you can now vary the location. Every time you open a door, you have no idea what's behind it. What's also nice is that you can simulate situations. Think for example of a situation at Amsterdam Central Station. There are so many irrelevant aspects there that draw and influence your attention. You really can't simulate that in a training house in real life."*

In conclusion, the trainees stated that the **VR scenarios contained relatively many elements of task-relevant information** (e.g. weapons, movement of suspect) and relatively few task-irrelevant information (e.g. a loud TV) that distracted them. The trainees suggested adding more distracting, irrelevant information to the VR scenario to better experience the difference between goal-directed attention and stimulus-directed attention and to train goal-directed attention in the presence of task-irrelevant stimuli. Many of these options are already possible in the SHOTPROS VR solution, but trainers need to get used to actually integrate these options. The need for more detailed environments was answered by the additional training environment based on the unreal graphic engine (see D5.1) where the level of detail of environments is much higher and more options of distraction are possible.

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The trainees seem convinced that VR offers an added value over real-life in practising staying focused on task-relevant stimuli in the presence of task-irrelevant stimuli, because the infrastructure of VR scenarios can be adapted quickly and repeatedly, thus avoiding habituation to the environment.

4.2 Validation of the model via semi-structured qualitative interviews

UHEI explored the links between officers' attention and subsequent DMA processes through short, semi-structured qualitative interviews. In order to capture the DMA processes and identify relevant human factors within the scenarios, the officers answered three brief open-ended questions following each scenario:

- "What did you pay attention to during the scenario?"
- "How did that influence your decision-making?"
- "How did you act during the scenario?"

Interviews were conducted directly after each scenario before officers had the opportunity to engage in conversations with each other or with the police trainers in order to prevent memory effects and interview biases caused by social exchange. The focus was on the officers' attention to, as well as evaluation of, personal, contextual, organizational and societal human factors (HF) during the scenarios (for a more detailed explanation, see D7.2). In total, qualitative interview data was gained from *N* = 68 police officers (*n* = 9 from Bucharest, *n* = 30 from Selm, *n* = 29 from Berlin). Officers were aged between 20 and 54 years (*M* = 34.14; *SD* = 7.73). Concerning service ranks, *n* = 7 were police students, whereas *n* = 52 worked as fully educated police officers. Service experience varied between 0 (police students) and 38 years (*M* = 11.33; *SD* = 9.04).

Overall, *N* = 1116 data units were extracted from the interview data from Selm and Berlin. One data unit consisted of one separate content component extracted from the text. For example, one officer stated *"[I paid attention] to usefully safeguarding my colleagues, observing the involved persons and watching their hands."* This statement was subsequently divided into three data units: Safety hazards (green), unclear parties (orange) and hands (blue). Data was analysed separately for the three interview questions regarding attention, decision-making and acting, in order to identify relevant and irrelevant cues and HF in the varying phases of the DMA process and integrate them into the overall model. An **overview of distribution** of data units on the separate research questions **regarding attention, decision-making and acting** is depicted in Figure 4.

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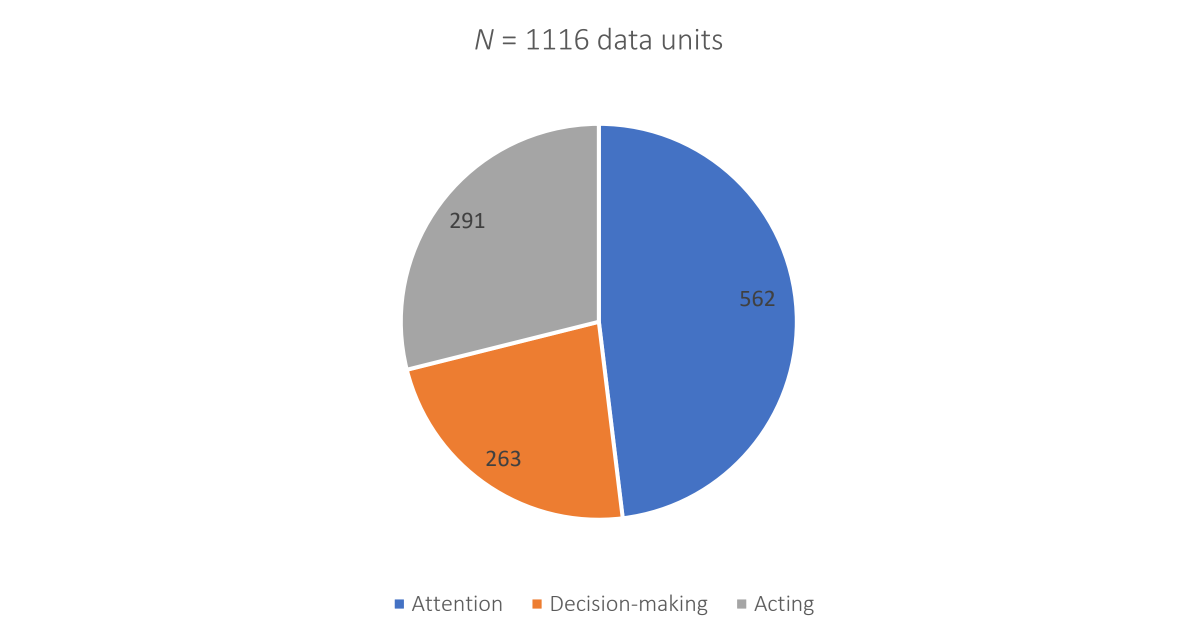

Figure 4. Overview of data units relating to attention, decision-making and acting.

4.2.1 What did trainees pay attention to during the scenario? – Input in DMA-Model

Concerning **attention**, *n* = 562 data units were extracted from the data, which marks the highest proportion of data units across the three interview questions. Officers were asked to indicate what they paid attention to during the scenarios. Data units concerning attention resulted in the following main categories: Features of the operating situation, involved parties, police action, perpetrator, teamwork, technical aspects of the VR system, cognitions, own behaviour and training contents.

Below are the findings for the categories most frequently mentioned by the officers in the interview. The findings for all other categories can be found in Table 3 at the end of this section.

Most frequently, officers' attention during the scenarios was captured by *features of the operating situation* (*n* = 220). Officers paid attention to *spatial features* present in the scenarios, such as general environmental characteristics. Those included houses, house numbers, rooms, walls, windows or open doors. For example, one officers stated *"[I paid attention to] the surroundings, house numbers, the whole housing complex. To the building, to what was placed on the ground. There were two benches, a window that you could look through. We couldn't directly stand in the door. And there were two cars parked at the side*."

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The position of colleagues relative to the officers' own position was also at the centre of the officers' attention, as officers frequently reported to adjust their own position in the room according to the position of their colleagues to guarantee the best possible line-up for the task ahead: *"[I paid attention] to my colleagues, to where they were standing, so we could create a good V-position*." Also, safety hazards, such as potentially dangerous persons or objects present in the scenario, firing lines, escape routes and avenues of attack were reported by the officers and categorized as features of the operating situation.

Visual cues of the operating situation were frequently mentioned. This included the position and movement of hands, both of the perpetrator as well as bystanders, as they were perceived as a potential danger to the officers because they were expected to hold onto weapons or other potentially dangerous objects or could be used to attack the officers: "*You always wanna see the hands first to get some feeling of security!*" Naturally, weapons resembled another visual feature that officers paid attention to during the scenarios: *"[I saw that] there was a weapon involved, a knife.*" Above that, ambiguous objects present in the operating situation that officers could not identify at first sight as well as blood stains on doors and walls were mentioned by the officers and classified as visual cues: "*I noticed blood stains and followed them along*."

Less frequently, *acoustic cues* present in the operating situation were noted by the officers. This included any kind of sound present in the situation, such as loud music playing in the background, the sounds of a party going on, shooting sounds or voices. For example, one officer stated: "*We instantly heard that there was a party going on somewhere*." Frequently, acoustic cues also allowed the officers to gain an understanding of the mood of the persons or crowd they were confronted with. For example, when they noticed party sounds, officers already expected the crowd to be drunk and in high spirits.

Least frequently, *known information* about the operating situation was mentioned by the officers. This included all information the officers received either before the start of the scenario or by radio during the scenario. For example, officers paid attention to information concerning the reasons for deployment, such as work orders, known background and characteristics of the perpetrator or severity and urgency of their deployment: "*Well, I knew beforehand that the scenario included an active shooter and required a VGBS action. So it was clear that there would be many bystanders, a highly dangerous perpetrator with the willingness to kill and hurt people, which called for an immediate intervention.*" Also, officers paid attention to operating resources they could use in the scenario, such as the selection of an appropriate weapon, the use of pepper spray or a taser.

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4.2.2 How did trainees' attention influence their decision-making? – Throughput in DMA-Model

Concerning **decision-making**, *n* = 263 data units were extracted from the data, which marks the lowest proportion of data units across the three interview questions. Officers had to indicate how their decision-making was influenced by the cues they paid attention to during the scenarios. Data units concerning decision-making resulted in the following main categories: Own behaviour, features of involved parties, environmental features, cognitions, communication within the team, technical aspects of the VR system, aid delivery, personal and interpersonal aspects and training memory.

As before, the findings for the categories most frequently mentioned by the officers are explained below, the findings for all other categories can be found in Table 3.

Most frequently, officers' decision-making was influenced by their *own behaviour* (*n* = 71). This mainly comprised the officers' *use of weapons*. For example, officers reported that they decided to prepare themselves for shooting, choosing an appropriate weapon for the situation, which for some officers ultimately resulted in the use of that weapon, i.e., shooting: "*I saw the person, he was approaching me with a dangerous object in his hand and didn't wanna remove it, so I shot at the person*." In addition, officers' *movements* were a subject of decision-making. For example, officers adjusted their own position based on their perceptions of the scenario. Some officers also adjusted or changed their direction of motion or viewing according to cues they perceived in the scenario. For example, they would move away from safety hazards they perceived, however, at the same time changing their direction of view to focus on those safety hazards: "*[What I perceived] gave away the way that I had to follow*."; "*[…] and also were I was looking*." One officer reported that what he perceived led him to decelerate his movements: "*That kind of paralyzed my movements, my running, a bit. I think we were just standing there unnecessarily for too many seconds*." *Perpetrator-related behaviours* were additionally reported to have resulted from attentional processes during the scenarios, including communication with, fighting against and identification of the perpetrator: "*Well, yeah, that kind of influenced my decision-making in a way that I now actually wanted to find the perpetrator and wanted to kill him. I wanted to fight him*." Finally, *defensive behaviour* resulted from perceived cues. Some officers reported that they tried to proceed as cautiously as possible during the scenarios, slowing down their speed of movement and trying to keep calm during the situation: "*I proceeded much more carefully, accordingly*." Sometimes, this cautious behaviour even led to the abortion of target actions, i. e. withdrawal from the situation, which was a sensible solution in some scenarios: "*It just wasn't possible to reach my goal in that moment. It just didn't make sense to execute the arrest warrant here and now, in front of all these people, and it also wouldn't have been possible. The situation*

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just wasn't right to reach my goal in the end." Partly, this was also due to the perception of restricted possibilities for action, as one officer reported. Overall, this category especially demonstrates the expected intertwining of decision-making and acting processes, with participants reporting perceived behaviour as a reason for their decision-making.

4.2.3 How did trainees behave during the scenario? – Output in DMA-Model

Finally, concerning **acting**, n = 291 data units were extracted from the data. Officers indicated how their decision-making processes influenced their subsequent behaviour. Data units concerning acting resulted in the following main categories: Fulfilment of police duties, defensive behaviour, evaluation processes, working together as a team, individual reaction patterns, use of (armed) force and technical aspects of the VR system.

The most frequently mentioned categories are explained below, the remainder can be found in Table 3 at the end of this section.

Most frequently, officers engaged in the *fulfilment of police duties* (*n* = 84). This included measures of *situation management*, such as backup tasks, gaining an overview of the situation, including all involved parties, objects and reasons for action, differentiation of perpetrators and victims and de-escalation of the situation, for example by trying to communicate with all involved parties instead of instantly applying force to solve the situation: "*I mainly took on backup tasks. Also later on, when the perpetrator was hit and laying on the ground, I just tried to keep up securing*." One officer also mentioned victim support as their direct action. In addition, *interaction with the perpetrator* was part of police duties: This included physical confrontation with the perpetrator, either when trying to fight him violently through the use of weapons or when confronting him only verbally: "*I went ahead and had contact with the perpetrator first and was able to talk him down. He did exactly what I asked him to do*.". Also, officers reported arresting the perpetrator or keeping him on distance as part of their actions during the scenarios: "*Well, I was standing next to my colleague and was just trying to keep him at an appropriate distance*." *Communication* duties included communication with involved parties, for example asking involved persons for their ID card and personal details or talking the perpetrator down: "*We wanted to see his ID card, and we communicated this clearly and with a certain determination*." One officer also requested support.

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***Table 3.** Remaining categories, code groups, quotes, explanations and implications/conclusions for the DMA-Model from the qualitative data.*

Category	Code Group	Quotes	Implications/Conclusions for DMA-Model
Attention (n = 562)	Involved parties (n = 181)	*"I was trying to check whether the description of the perpetrator matched with the persons I was seeing."*	Police officers directed their attention most commonly to the environment and involved objects and persons in order to evaluate the risk and danger within the given circumstances. Human factors, such as the perpetrator and the team, were also commonly attended.
	Police action (n = 59)	*"I took on the task to secure the area behind our backs, so no one else would come, checking that nobody was looking outside the windows. Just securing the area around us."*	
	Perpetrator (n = 54)	*"My focus clearly was on the localization of the perpetrator."*	
	Teamwork (n = 22)	*"I paid attention to staying together with the colleagues. We wanted to keep a ballistic protection."*	
	Technical aspects of VR system (n =14)	*"[I was trying to pay attention] to my own people, however, they were kind of distorted. And when I was trying to reach body contact something didn't work out. In VR, I was kind of already going through my partner, while in real life I didn't even reach him physically."*	
	Cognitions (n = 6)	*"There were so many influences raining down on me."*	
	Own behaviour (n = 5)	*"[I was paying attention to] how I could react as fast as possible in the situation."*	

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	Disagreement (n = 1)	*"My colleagues partly had different views than me."*	
Decision-making (n = 263)	Features of involved parties (n = 50)	*"My decision to pull the gun was made, because he was carrying a dangerous object, in this case it was a hammer, which he could have used to smash my head."*	Decision-making was most commonly influenced by the officers' own behaviour, the other involved parties and environmental features. The decision-making seems to have been influenced only by relevant features vital to finding a suitable conclusion. Participants perceived weapons and the aggressors as threatening, triggering decisions to ensure safety.
	Environmental features (n = 40)	*"In the end, I adjusted my own position according to the position of the other people involved in the situation, especially those we were talking to."*	
	Cognitions (n = 38)	*"Overall, it was a very chaotic scenario. There are so many people running around and you don't know where they're going. And you also don't know how many perpetrators there are."*	
	Communication within the Team (n = 24)	*"I saw that the first two colleagues were looking straight ahead, one looked to the side. So, it made sense for me to cover the back area."*	
	Technical aspects of the VR system (n = 12)	*"I hesitated because I couldn't clearly see the weapon, because the goggles had moved a bit and I couldn't see sharply."*	
	Aid delivery (n = 7)	*"There were my two injured colleagues, I couldn't just leave them back there, right?"*	

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	Personal and interpersonal aspects (n = 6)	*"So many people… I also experienced this in the past, and how easily such a situation can shift. So, I was a bit more stressed."*	
	Training memory (n = 6)	*"This led me to recall reaction patterns that we have learned in police training."*	
	No need to engage in decision-making processes (n = 9)		
Acting (n = 291)	Defensive behaviour (n = 53)	*"I behaved rather passively and did not take part in the communication with the perpetrator."*	Most of the officers orientated their behaviour by the behaviour of their respective team members. Most of the officers behaved rather defensively and passively and let the leader take on more offensive behaviour. Also, the perceived stress varied across the officers and only a few actually used armed force.
	Evaluation processes (n = 51)	*"I have to say, I behaved just as I would have done in a real police situation."*	
	Working together as a team (n = 39)	*"I tried to stick to the second man. He discovered the perpetrator over there. He saw him standing in the door, I couldn't see that. So I stuck to him."*	
	Individual reaction patterns (n = 21)	*"I was stressed. Especially when you see how your colleagues get hurt. When hurt people come running towards you."*	
	Use of (armed) force (n = 13)	*"I shot at the perpetrator on the first floor."*	

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	Offensive behaviour (n = 10)	*"You got a bit braver, more active, trying out your limits. And well, yeah, you could venture a bit more forward based on the experiences you made."*	
	Behavioural limitations relating to the VR system (n = 8)	*"It just wasn't working. I saw everything distortedly. The people I was seeing weren't actually where they were displayed to me. Accordingly, I couldn't really process the scenario."*	
	Killed (n = 12)		

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4.2.4 Conclusions for the DMA-Model

Officers' **attention was mainly captured by features of the operating situation, involved parties** (including the perpetrator, which was defined as a separate category) and **associated features relevant for police behavior**. Interestingly, training contents were hardly attended to, however, this might also be due to the nature of the interview question, with officers mainly mentioning **cues that were physically present** within the situation and less frequently mentioning cues that they only attended to mentally. Although officers were well able to indicate cues that they paid attention to during the scenarios, they found it harder to express how those cues influenced their subsequent decision-making, with some officers directly expressing that they did not see any connection between their attentional processes and their subsequent decision-making. Officers **partly expressed reasons for their behavior** when answering this question, while some officers also described **their own behavior as being responsible for their decision-making**. This strengthens the proposition stated by the model that decision-making and acting represent two interlinked processes that cannot be artificially divided. Surprisingly, memory of training objectives was hardly ever mentioned as being responsible for officers' decision-making during the scenarios. Some officers even indicated that they took all of their decisions intuitively. Possibly, the stressful scenarios and the presence of multiple cues at the same time, combined with the presence of at least one perpetrator, led the officers to follow embodied choices and motor heuristics, which are rather implicit processes, more strongly during the scenarios instead of focusing on what they remembered from police training in order to solve the scenarios. Finally, concerning acting, as expected, officers most frequently engaged in police behavior in order to solve the scenarios. Interestingly, officers only rarely mentioned the use of armed force, even though especially the third, most stressful scenario almost always actually required the officers to shoot. In this context, one officer even mentioned that they perceived a certain inhibition to shoot. Generally, officers more frequently reported specific police behavior in this question as compared to individual reaction patterns, which can be considered a surprising finding against the background that officers hardly ever mentioned police training contents as responsible for their actions. Hence, more individualized reaction patterns could have been expected. Interestingly, officers frequently not only reported on their specific behavior when answering this question but also automatically engaged in evaluating their behavior, displaying a realistic approach to the assessment of the situation. This also included the role of technical aspects relating to VR.

Overall, the **qualitative data gained from the short interviews** conducted directly after each scenario **adds to the model by providing first-hand information from the officers directly after their participation in the scenarios**. Hence, this information must be considered unaltered and is expected to not be influenced by any memory biases which might develop after participation in the testing. In this context, especially the first question on attentional processes during the scenarios informs on cognitive and sensory information present in the scenarios (1) as well as human factors that evoke stress (2). In combination with police guidelines, this information can be used to evaluate whether officers used task-relevant or -irrelevant information in order to solve the scenarios (3). Finally, questions two and three, relating to decision-making and acting, respectively, indicate the presence of a multitude of possible decisions and actions (4). Here, it is of importance to note that the conscious separation of decision-making and acting processes through the two separate interview questions tested and strengthened the general assumption of the model that both processes are intertwined directly.

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5 Strength of the Model's Implications for VR Training

In Chapter 4, we have presented how user experiences of trainees in VR align with several core tenets of the HF model for DMA-SR. These results, together with the research conducted in SHOTPROS (see D6.1), provide insight into the strength of the model's implications for VR training. The **usability** and **credibility** of these implications stand or fall with the strength of the model.

5.1 Implications of the model: conclusions on efficacy for VR training

The input of the model are the human factors that determine whether a situation is potentially stressful and high-risk. The results of the trainees' experiences demonstrate the **usefulness of the model's input for VR** since:

- Stress is evoked in VR training and VR scenarios include human factors (particularly contextual factors) that induce stress. It can be concluded that **VR training is useful for manipulating all components of the stress response** to suit training needs and allows for optimal training of mitigation strategies (i.e., training for goal-directed attention control).
- VR training can incorporate both **task-relevant** and **task-irrelevant** stimuli to experience the difference between goal-directed attention and stimulus-directed attention and to train goal-directed attention in the presence of task-irrelevant stimuli. However, trainees suggest adding more distracting information (task-irrelevant stimuli) to the VR scenarios (e.g., clutter, objects, and sounds) to optimise their training with mitigation strategies in VR.

It is **important** to realise that **human factors** in VR training must be scaffolded in a **proper didactical way**. For example, prevent scenarios from being too overwhelming, as the novelty of VR can lead to increased mental effort within trainees (see D3.3, *table 12*). For more information on how to incorporate human factors (particularly contextual factors) that induce stress into VR scenarios in a proper didactical way, see the didactical guidelines of *well-designed practice situations, high-quality training instruction, and clear training assignments* in D7.5.

The throughput of the model dictates that attentional control is required in VR training to execute the scenario successfully, despite experiencing stress. The results of the trainees' experiences demonstrate the usefulness and credibility of the model's throughput for VR since:

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- In stressful conditions, trainees report that their **attention** in VR **was "hijacked" by stimuli that were not relevant** to the task. As a result, they had to exert extra (mental) effort to maintain or restore their attention to the task or were sometimes not able to mitigate the stress response, leading to suboptimal DMA. This validates the model's implication that the stress response makes it easier for the trainee to be distracted and harder to redirect attention in VR.
- Trainees indicate that they could **restore or maintain goal-directed behaviour** as much as possible despite being confronted with stressful circumstances. VR thus allows trainees to practice strategies to mitigate the adverse effects of altered attention control and maintain acceptable performance standards. This also confirms that according to the model, in VR, attentional control directs decision-making and acting through the operational levels of attention, interpretation, and response formation.

The model's output requires that ecologically valid cognitive and sensory inputs are present in VR training, as these dictate eventual actions (embodied choices and motor heuristics). The results of the trainees' experiences demonstrate the usefulness of the model's output for VR since:

- Trainees report that **they could perceive, move and process information naturally** in VR. This provides trainees with unique opportunities to discover and imprint the correct motor heuristics. Both **realistic cognitive and sensory input** should be carefully considered in the further technological development of VR systems because the current limitations of VR technology, such as limited facial expressions and the inability to see emotions, can affect trainees' habitual decision-making and actions and limit the imprinting of applicable motor heuristics and embodied choices. Some inputs on that were already tested in the experimental environment with the more detailed graphical visualisation (see D5.1 and D7.6) and showed better feedback on that topic.
- Trainees indicate that their own behaviour largely influenced their decision-making. This reinforces the model's assumption that decision-making and action do not appear to be consecutive stages of action but integrated processes, and emphasises the importance of **reflecting on the trainees' actions as a whole** in VR (the what and how of the action and action possibilities) rather than a repetition of cognitive decision-making alone, or a separate evaluation of physical/technical skill acquisition.

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6 Four Key Messages from the HF model for DMA-SR

The North Rhine-Westphalia Police Force (LAFP NRW) and other LEAs selected four key messages from the model. These implications of the model stood out for the LEAs in developing and designing a VR training for police officers to train their decision-making and acting in stressful, high-risk situations. We asked the LEAs to reflect on how they incorporated each key message into the field trials or other VR training. In addition, we asked the VR partner (RE-LiON) to describe how each key message is incorporated into the system and what requirements (not yet implemented) remain.

6.1 The VR-system should allow officers with natural ways of perceiving, moving and processing information

In real life, we have cognitions and feelings, use knowledge and bodily skills, and experience both cognitive and sensory input. In short, we use **cognitive** and **sensory** information to think and act. For more explanation on cognitive and sensory information, see D3.2.

For training to be of any use, we need to be able to think and act as normal as possible. In VR, this is not a given. For example, the sensory information is not realistic if an officer cannot use the same weapon and weapon technique they normally use in practice. If officers are mentally overloaded by the novelty of a VR experience, they may not be able to think or use their knowledge normally. Therefore, thinking and acting as normal as possible should always require extra attention in VR training.

LEA Perspective

The question we ask ourselves is, do we train as we fight? To achieve this, we need both realistic cognitive input and sensory input. To be able to think and act in a natural way starts with the preparation for a situation. In our VR training we ensure that it is possible for trainees to mentally prepare themselves and visualise approaches and tactics.

In addition, we work with training maps that represent "life-like" environments, where we can quickly switch between different environments. In these environments, trainees must be able to communicate as in real life, and rules and laws are applied as in real life.

The SHOTPROS tactical belt plays an essential role. In the SHOTPROS field trial in Selm, we made sure that the trainees had the same tools and resources at their disposal as in real life and that the task of choosing which means of violence to use in which situation could be manipulated in VR.

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In our VR training, we prefer (for relevant roles) a human role-player to an NPC. Role-player behaviour is more realistic, especially when it comes to communication.

Haptic feedback from the training environment should be added, such as sensory feedback from virtual walls and a pain stimulus. Furthermore, it would be useful if a system makes use of the 4th dimension (temperature, humidity, wind, etc.), the scenarios in a VR system have realistic timelines and show absolute distances.

Especially this feedback was tested in the experimental environment which (due to time and resources – see D5.1) was not able to be included in the full SHOTPROS VR solution but needs to be integrated in an exploitable solution (see D7.6) and received good feedback and data on that integration (see D7.6).

Technology Partner Perspective

Realism was frequent feedback mentioned during the end user feedback weeks and therefore an important part of the backlog (see D4.6). In the SHOTPROS VR solution and its additional experimental environment, we ensure that trainees perceive the environment as naturally as possible by making both audio (e.g. spatial sound) and video similar to what happens in the physical world. It is also important that the trainer reacts to the needs of the trainees and the flow of the training by adapting the scenario in the Trainer Dashboard (see D4.5) and adding/removing stress inducing factors. For this experience also the unreal environment was set up in addition to the standard SHOTPROS VR solution to be able to add additional sensors like smell, humidity, wind, more detailed and more realistic graphic etc. (e.g. enhanced environments with more crowds in the background, driving cars, litter or other details that make an environment lively etc.) To further enhance the sensory and cognitive inputs and make the acting more natural for the trainee, the addition of smell was also mentioned by users and added to both systems during selected field trials (e.g. petrol puddles on the floor that actually smell like petrol).

By fully detecting the movement by the suit that the trainees wear, we are able to translate their movements into their digital avatar which in turn enhances the perception of realism.

6.2 The VR-system includes human factors that are known to be stressful or indicate risk.

For training decision-making and acting under stressful and high-risk circumstances, we need to create stressful and high-risk circumstances. The amount of stress and the exact triggers or **stimuli that cause stress** will **vary from officer to officer**. To make stress (and high risk) as likely as possible to occur, we should make use of the human factors that are known to be stressful or indicate risk. In the SHOTPROS HF model for DMA-SR, we include **personal** (e.g.,

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experience, uncertainty about abilities), **contextual** (e.g., the unexpected and the unknown), **organisational** (e.g., rules and regulations), and **societal** *factors* (e.g., media and perception of the police) based on the professional experiences of officers and police trainers (see D2.1) and research literature on the topic (see D3.2). Within SHOTPROS, the risk assessment tool (see D4.7) was developed to help incorporate stressful human factors in training scenarios.

LEA Perspective

*In VR, we have to take into account that trainees (especially the first few times in VR but also depending on their real-life experience as officers) can be **overwhelmed** by the environment, which takes up **mental space**. Therefore, it is important **to keep the number of stressors limited** in the beginning and to build it up slowly. Although VR technology is able to create infinite environments and situations, the idea is not to always create as much stress as possible in the VR scenario, as this can actually limit learning. The question we always ask is: How many objective stressors do I use in a scenario to create a **positive learning curve**?*

*A big advantage of VR is that you can **quickly adjust** the complexity of a scenario by adding or removing stressors, so you can perfectly take into account the individual **experience, mental load** and **learning curve** of the **trainee**. Human factors by which we consciously manipulate the environment include for example the presence or absence of weapons, few or many people or animals in the environment, and the appearance of the environment, such as noises. In an outdoor environment you can also think about remarks from bystanders, people filming, flash advertisements and traffic to make the scenarios more complex.*

Technology Partner Perspective

The current VR system integrates personal or contextual human factors through automatic triggers or manual stressors via the Trainer Dashboard (see D4.6) or via the operator. The instructor can choose to adapt the scenario with more or less stressors during the scenario, also depending on the live stress levels of the trainees and learning goals; add more or remove. Human factors can be built into a scenario beforehand in the scenario designer (see D5.1) but can also be inserted or removed on spot during the execution of the scenarios (see D4.6). Although the contextual human factors are the most obvious and easiest measures being used in VR, all other human factors can also be included:

Type of human factor	***Examples*** **how to be integrated in the SHOTPROS VR solution**
Personal	Creating situations where the skills of an officer or the team are by definition not enough (and the objective is to get an additional team via dispatcher and not to start the operation)

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	Or on purpose including stereotyped situations which appear to be different (e.g. the female person is the perpetrator instead of the male person) Etc.
Contextual	Adding bystanders where not expected or on purpose in the line of fire of the police officer Adding children or elderly people to high risk situations including sound Adding smell to a liquid on the floor (e.g. more dangerous smell like petrol or just distracting smell like urine) Making a mobile phone ringing again and again on high volume Etc.
Organisational	Analysing the use of force in the after-action review by jumping exactly to the situations and the perspectives where it happened. Analysing certain regulations during after-action review by creating markers during the training (bookmarks set by the trainer) and then reviewing exactly from this position. Etc.
Societal	Including media reports of real-life operations (that have been re-produced in VR for training attempts) to show trainees how certain actions cause certain societal reactions. Including avatars in the scenarios filming or asking to sensitive situations. Etc.

6.3 In the VR-system, attentional processes should be challenging (task-relevant and task-irrelevant information is present)

As explained in the model, **stress causes attentional changes**. For an explanation of these changes, see D3.2. In short, under stress, we may become distracted from goal- or task-relevant information and instead focus on task-irrelevant information and thoughts (e.g., all kinds of worries). This can lead to suboptimal decisions and actions.

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So, the training objective is to remain goal-directed and keep focused on task-relevant information, despite elevated stress levels. If we want to have officers practice controlling their attention, then training scenarios should include both task-relevant stimuli and distracting, task-irrelevant stimuli. If we would have a scenario that is **too simple** (all information is task-relevant, there are no distractors), **attention is not challenged**, even though stress can be present in such a simple scenario. There are simply non- external stimuli to be distracted by. If we include both task-relevant and task-irrelevant stimuli (and practice with realistic, elevated stress levels), officers can learn to stay focused on task-relevant information and mitigate attentional changes that the stress will cause.

LEA Perspective

Since the participants were unfamiliar with a VR training system, we used our technical partner's tutorial and calibration process as an initial tool for our trainees to get used to (task-relevant and task-irrelevant stimuli in) the environment.

The fact that all the tools for the use of force (baton, electroshock gun, weapon etc.) were present and available in the VR scenarios helped to keep minds "open" and provoked trainees to scan the environment carefully and not just start moving around the scenario with the gun unholstered just because of the fact only the weapon is available. This learning was created in one of the very first SHOTPROS end user feedback weeks (see D4.6 requirements), whereupon the tutorial scenario and also the availability and the handling of forces was changed to avoid this. In addition, we kept dispatch communication at a realistic high level in each scenario. Dispatch communication is a powerful stimulus that is not always "task-relevant" for police officers but can be very distracting. The fact that trainees have to choose and hesitate between engaging in a potentially violent encounter, communicating with a person/threat present, or deciding to communicate with the higher authority of your dispatch is certainly a distracting realistic stimulus.

In addition, we intentionally placed injured and/or submissive innocent bystanders in the scenarios that needed to be evacuated from dangerous areas via communication. The trainees were triggered to distinguish between task-relevant and task-irrelevant stimuli. The level of injuries used had a high potential to make officers more alarmed. This forced them into the decision-making process of offering "first aid"/communicating with the emergency services center to evacuate or staying with their objective of containing the threat and ending it as a first responder.

Lastly, we used no scenario without the possible threat of injuring innocent bystanders or victims by using lethal force against the perpetrator. With success, we even had avatars flee

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through lines of fire to distract trainees and force active shoot/no shoot decisions which generated high relevant learning situations.

Technology Partner Perspective

The current SHOTPROS VR solution ensures that task-relevant is present by means of trigger or manual insertion of stimuli through the scenario design and the Trainer Dashboard as well as the options available for the operator (which are similar to the scenario designer options and less than the trainer options).This also applies for task-irrelevant stimuli. For example, the sound of a barking dog (without a visual dog) or a ringing phone can distract while being completely irrelevant for the situation the officer actually has to deal with, for example a domestic violence situation between two residents.

6.4 The VR-system allows trainees to choose between multiple decisions/actions

Decision-making and acting for police officers is about **choosing the least violent option** but to still bring a situation under control. **Proportional** and **subsidiary action** is always the aim. There is a difference between training one specific skill set, that is, the execution of one specific decision (to shoot, for example), and **training in deciding between different options** (de-escalate by communication versus the use of a taser or pepper spray for example). Although VR can be used for specific skill sets, the aim in SHOTPROS is on the latter objective for decision making and acting.

In that context, to train decision-making and acting, there should be at least two options to choose from (ideally more, as most of the time, in real life, there is a plethora of options). Simply put, if in a VR scenario the only option or obvious right decision is to shoot a perpetrator shooting with a gun at the officer, then not much decision-making is required. **Ideally, VR scenarios have police officers practice with situations that can be resolved in many different ways**, and they actually have to select (one of) the most proper line of decisions and actions.

LEA Perspective

It is essential to give the trainees scenarios in which they have to decide what to focus their attention on (perception) and explore possibilities for action (e.g., what is the most appropriate solution in this situation?). We have sought to translate this into the scenarios used in the field trials:

In scenario one, we chose as background a fight between a couple in a furniture shop. Here the trainees had to choose and decide from the full range of possibilities of communication,

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giving orders, selecting the right legal approach, and the option to use force. It was meant to be a "no shoot scenario".

Scenario two increased the threat level to an escalation of the fight from scenario one into a knife fight with multiple injuries. Although the threat level was such that it was clear that the officers had to intervene and locate and arrest the suspect, several decisions had to be made, e.g., what was the appropriate legal use of force against the suspect (what means of force do we use?). The scenario was designed so that "lethal force was possible", but still a "no shoot scenario" when trainees used the right tactics (choices) and perception.

Scenario three resembled a terrorist attack by two armed perpetrators in the same location. After the "prelude" in scenario 2, the objective was clear. However, by adding the presence of (more) innocent civilians and the pressure of communication with your teammates, dispatch and civilians, and perpetrators, there were still different courses of action and choices to be made. Furthermore, by having the terrorists act in different areas of the environment (furniture shop with a surrounding), there was always the element of orientation present and the need to reassess the situation (bystanders, teammates, etc.). So, although designed as an apparent "Shoot to end threat" scenario, there were so many "don't shoot" decisions to be made that it was a difficult task for our agents. In both the studies and the practical test, almost no civilians were shot.

Technology Partner Perspective

The SHOTRPROS VR solution allows trainees to practice choosing between different decision and action options to meet the demands of a situation because the environments give trainees information to explore different options to respond to the demands of a situation (e.g., violent behaviour, de-escalating behaviour, running away, etc.). Although scenarios can be pre-scripted (e.g. by using trigger zones that execute a certain reaction (e.g. shooting noises in the next room) or change in the situation (addition of a barking dog) or certain behaviour of an avatar (e.g., running a dedicated path etc.) whenever this triggerzone is passed by the trainees (e.g. crossing the entrance of a building), the scenario "reacts" on the DMA of the trainees and thereby makes the next DMA individual choose able again. By this, the options of police behaviour are limitless, and trainers additionally can influence this flow by, e.g., changing the scenario (flow, environments, objects, sounds etc.) or the avatar behaviour, giving the role players direct instructions (non-audible by the trainees) or by moving themselves around in the VR in a ghost mode and then "jumping" in any character and reacting on the trainee's DMA to evoke additional DMA. For example, the SHOTPROS VR solution provides default avatar behaviour (cooperative, aggressive etc.) and can also react on click with pre-defined actions or individually assigned actions. By this, the trainee has to switch quickly between different options. The VR offers the trainees different means (e.g., baton, pepper spray) they can use

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and from which they must choose the appropriate and proportional use of forces for a situation.

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