Human Behavior Nearby an Explosion – Characterization for Military Use

Research conducted by Philip Tannor (CPT.),
and supervised by Eran Yehuda (LTC.)

Abstract

1. While planning military operations, developing new weaponry and constructing drills for different units of the Israel Defense Forces (IDF), it would be helpful to be able to predict the behavior of an enemy after an explosion occurs nearby. Specifically, many times there is a need to predict the amount of time it takes for a person to escape from the room he is in.
2. The main objective of the research is to estimate the amount of time required by a person to escape a room, after being surprised by an explosion occurring in another room in the building. The emphasis of the research is on estimating the "worst-case" scenario, in which the escaping is conducted quickly. A secondary objective is to improve our general understanding of people's behavior after an explosion occurs in their vicinity.
3. The research is based on an analysis of various videos (found on the internet), in which the behavior of civilians has been recorded, after they have been surprised by a nearby explosion.
4. The results of the research have been widely accepted by the Israeli OR community, and have been used for outlining operational requirements by IDF R&D officers.
5. This version of the paper, which has been authorized for public release, does not contain the precise figures and results from the original research. Still, the methodology of this research may inspire other research which will use similar methodology, and therefore is still worthy of discussion. Furthermore, researchers interested in precise information regarding this research are welcome to contact the author of this paper and request the information.

Background

6. While planning military operations, developing new weaponry and developing drills for different military units it would be helpful to be able to predict the behavior of an enemy after an explosion occurs nearby. Specifically, many times there is a need to predict the amount of time it takes for a person to escape from the room he is in.

7. In the literature we surveyed, no quantitative assessment of how long it takes for a person to react to an explosion within a building was found (specifically, no assessment was found for the amount of time it takes for a person to escape the room he was in). In addition, as far as we knew when we began conducting this research, no conventional assessment on the matter existed within the Israeli military Operations Research community.

Objective

8. The main objective of the research is to estimate the amount of time required by a person to escape a room, after being surprised by an explosion occurring in another room in the building. The emphasis of the research is on estimating the "worst-case" scenario, in which the escaping is conducted quickly. A secondary objective is to improve our general understanding of people's behavior after an explosion occurs in their vicinity.

9. The focus of the research is on military or guerrilla organization personal, which are while partaking in routine activities, combat preparation or command and control activities within a building (and not while actively fighting).

Method

10. The research is based on analyzing videos from the internet in which people are seen reacting to explosions in their vicinity, in an urban environment. Most videos show areas that were close to a surprising explosion, captured via security cameras.

11. If several people are seen in the same video, each person is analyzed individually.

Demarcation and Assumptions

12. The research deals only with the case of an urban-area explosion. In our opinion, the conclusions of this research cannot be extrapolated to predict the behavior of people in an open area.

13. The focus of the research is on the behavior of military or guerrilla organization personal, and not on the behavior of ordinary civilians.

14. Using this outline, we will try to predict the behavior of a person who is in a certain room, while an explosion occurs in a different room in the same building. We assume that anyone located in the same room in which the explosion occurred will not be physically able to escape the room quickly.

15. We assume that the explosion comes as a **surprise** to the person in whom we are interested. For example, in the case that the person hears explosions in nearby buildings, or is just about to leave or enter the room[1] when the explosion occurs, our results are not relevant.

16. We did not take into account scenarios in which people stall in order to aid others, or to promote the interests of the organization that they are affiliated with[2]. Also, we did not take into account scenarios in which people stall due to inefficient actions[3]. The reasons for this are:

    a. The main goal of this project is to provide an estimate for the **minimal** amount of time required for escaping, which clearly is not the case when inefficient stalling takes place.

    b. It is difficult to generalize behavior that includes inefficient stalling, because the variety of possible actions is much larger in cases of this sort.

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[1] While leaving or entering the room, the person of interest is most likely standing up, already in motion, and very close to the exit. These characteristics will probably make the response quicker then we may conclude in this research.

[2] From studying human behavior during the events of Sept. 11th, it seems that many people did conduct "selfless" actions like this before attempting to escape, such as saving important information on their computer, storing important items in safes, and even locking their office.

[3] For example, when someone is frightened and freezes in his place.

Findings

Preliminary Analysis

17. After searching the web fairly thoroughly, 10 relevant videos were located. From these videos, we were able to analyze the behavior of 25 different people.

18. In [figure 1], we can see the total amount of time between the explosion and the exiting of the room:

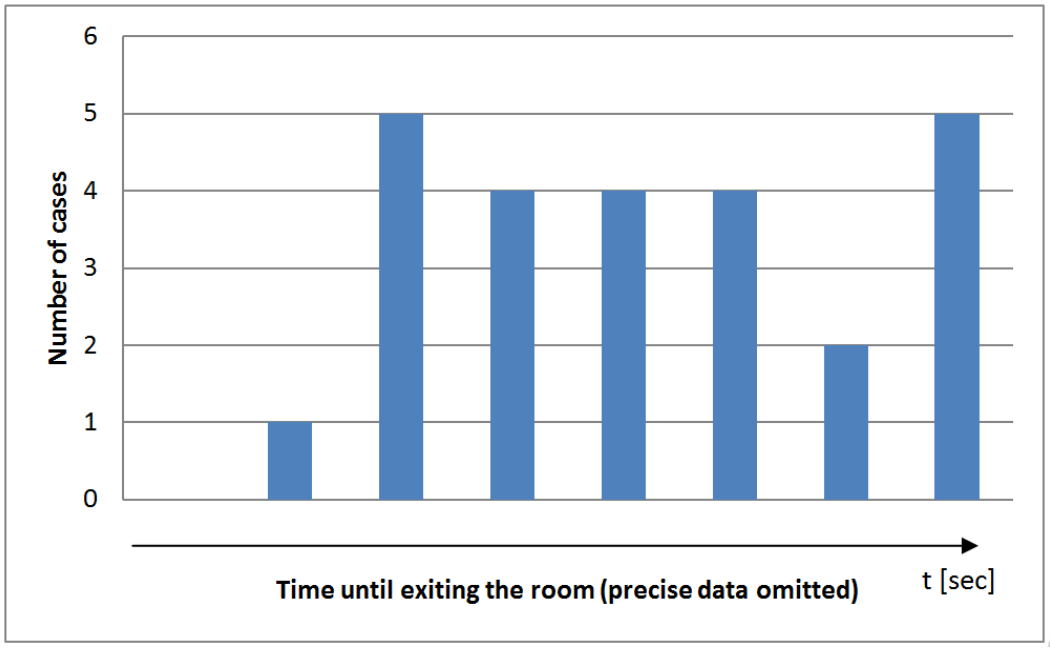

Figure 1: *Time from the explosion until the exiting from the room, as seen in the original cases which were analyzed. For precise figures please contact the author of this paper.*

19. Since the purpose of the research is to provide an estimate of the **minimal** amount of time required for someone to escape a room, the following comments must be made:

    a. Due to the fairly small sample size (25 analyzed cases), the shortest amount of time from the samples cannot necessarily serve as an estimate for the minimal "escape time" expected.

b. The measured "escape times" would probably have been shorter if the people in the videos were military or guerrilla organization personnel. There are major differences between the people viewed in the videos and military or guerrilla personnel, which may have an effect on the results:

1) In the analyzed videos, there are people from a wide range of ages (which presumably also affects their physical fitness) and includes both women and men, unlike the scenarios in which we are interested.

2) Military or guerrilla personal will usually have combat training, and some may even trained specifically for scenarios which include nearby explosions.

20. Therefore, there is a need for an estimate of the minimal amount of time from the explosion until exiting the room, based on a more detailed analysis.

Detailed Analysis

21. In addition to measuring the amount of time between the explosion and the exiting of the room (as presented so far), we categorized the different phases which people went through as part of their reaction, and measured the amount of time each phase took.

22. After the categorization, we reassembled the different phases as a Gantt chart, in order to model the operational process which we expect in the military/guerrilla organization case.

23. The different phases which appeared in the videos were as follows (not all of the phases occur in every case we studied):

a. Recovering from the primary shock;

b. Stalling;

c. Assuming a defensive position;

d. Remaining in a defensive position;

e. Running towards a nearby exit.

24. In the analyzed videos, people's reactions to the explosions were divided into several patterns:

    a. Recovering from the primary shock, running to a nearby exit

    b. Recovering from the primary shock, assuming a defensive position, remaining in a defensive position, running to a nearby exit

    c. Recovering from the primary shock, stalling, running to a nearby exit

25. We can represent these series of actions in the form of a Gantt chart:

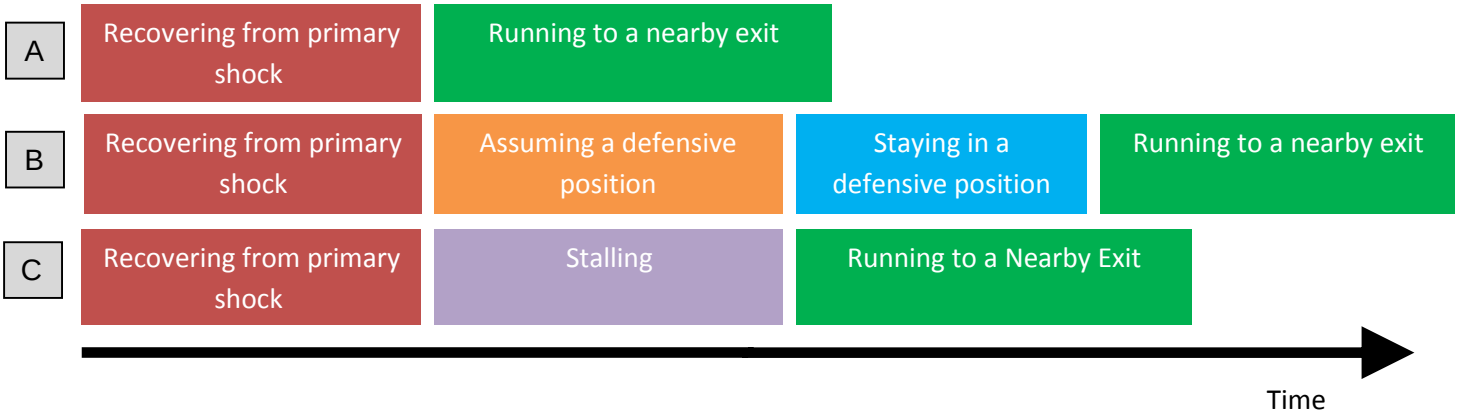

Figure 2: *A Gantt chart which describes people's reactions to the explosion, separated into different patterns, on a time scale. Proportions do not represent the amount of time that each phase took.*

26. After summing the lowest amount of time required in each phase, we can get estimates for the minimal amount of time required to escape the room.

27. Comments:

    a. The time it takes for recovering from the primary shock is dependent on whether or not the person experienced a significant physical shock or not, and more importantly, whether he was he knocked down or not. Therefore, later on we will separate between these two cases.

    b. Case C. from [figure 2] was not taken into account, since we assumed that stalling does not appear in the cases that we are interested in (as explained in paragraph 16 above).

28. In order to estimate the amount of time between the explosion and the exiting of the room, we addressed four cases: escaping immediately after the explosion, or after defending; with a significant physical shock or without. We shall summarize these estimates in [table 1].

	Without a significant physical shock	With a significant physical shock
Escape immediately after explosion	Very quickly	Quickly
Escape after assuming defensive position	Quickly	After a while

Table 1: *Estimates of the "escape time", i.e., of the time between the moment of the explosion and the moment of exiting the room, which were made using Gantt charts. For the precise figures, please contact the author of this paper.*

Using the Results for Practical Problems

29. The figures from this research can aid in both tactical situations, for planning an attack of a target, and in arms development processes, when defining the operational requirements of new weaponry.

30. In some cases, it is important to predict the "escape time", in a scenario of a quick and immediate escape (henceforth this shall be referred to as the "most severe scenario").

31. Even so, sometimes even a very talented enemy may not escape immediately, and therefore it is important to also use another estimate for the "escape time", in which we will assume that the enemy is less-than-perfect (henceforth this shall be referred to as the "moderate-severe scenario").

32. Finding a rigorous method for determining the "moderate-severe scenario" figures is not a simple problem, and yet the importance of a less "strict" working point was very important for some of the applications of this research. We used two different methods, and reached similar results in both cases:

    a. Manipulating the figures from [table 1], in a manner that simulated having slowed down somewhat during one of the different phases described.

b. Using the 10th percentile from our preliminary findings (as seen in [figure 1] at the beginning of the paper). This was done after separating between cases in which the person experienced a significant physical shock, and cases in which he didn't. This method provides a rather severe value, but not the most severe.

33. After determining the values for each one of the scenarios, we can present the following table, which concludes the research. The table may seem very similar to [table 1], but the actual values vary.

	Without a significant physical shock	With a significant physical shock
"Most-severe" scenario	Very quickly	Quickly
"Moderate-severe" scenario	Quickly	After a while

Table 2: *Recommended assumptions of the enemy's "escape time", i.e., the time between the moment of the explosion and the moment of exiting the room. For the precise figures, please contact the author of this paper.*

Summary and Conclusions

34. Dividing [table 2] into two columns (with/without a significant physical shock) allows us to match the chosen value to its corresponding tactical use. This is because it is possible to predict if a person will experience a significant physical shock from an explosion, according to: the expected intensity of the explosion, the distance between the rooms, etc.

35. In scenarios in which there are a few people in the room, the expected "escape time" is only valid for the **first person to leave the room**. In the videos that we have encountered, it is evident that in scenarios of this sort, the social dynamics and the physical bottlenecks (such as the entrance) can slow down the escape significantly.

36. It is important to take into account that the research was conducted for “severe” scenarios only. It is possible that in many cases the real "escape time" will be longer than we expected, as a result of elements that the research did not consider (e.g. people who have been wounded themselves, extraction of other wounded people from the room, room openings which have been blocked because of the explosion, etc.).

37. Furthermore, the single “most-severe” value (top left value in [table 2]) should only be used when it is clearly necessary. For the “most-severe” scenario to actually occur, all of the following conditions must apply:

    a. The person does not experience a significant physical shock.

    b. The person does not assume a defensive position or stall.

    c. The person does not slow down at any point until leaving the room.

38. The method of study used in this research (using internet videos as high-resolution data), is fairly new in the Israeli OR community. Studies like this may be useful in other fields as well, and in some cases may prove more realistic than using data from experiments.