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Implementation Intentions and Artificial Agents

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Abstract

We have developed a computer simulation comparing the behavior of two artificial agents (A0 and A1), both of which imitate the use of implementation intentions for achieving a goal R. However, A0 is more balanced for obtaining the goal intention "I intend to achieve R!" while A1 is more balanced for obtaining the implementation intention "I intend to do R when situations L are encountered!". We have accomplished the statistical analysis (including confidence intervals) and A1 improved the global performance of A0. Our simulation confirms partially the relevance of implementation intentions for social cognition in humans.
Key words: social cognition, implementation intentions, artificial intelligence, computational simulation.

Resumen

En este artículo presentamos una simulación por ordenador que busca comparar la conducta de dos agentes artificiales (A0 y A1) que imitan el uso de intenciones de implementación para alcanzar una meta R. Sin embargo, el agente A0 está más inclinado a ejecutar la intención simple "¡Intento alcanzar R!", mientras que el agente A1 tiene una mayor inclinación a cumplir la intención de implementación "¡Intento alcanzar R cuando voy encontrando las situaciones L!" Hemos tomado como referencia los parámetros introducidos en el estudio meta-analítico más amplio existente sobre el efecto de tales intenciones. Al realizar el análisis estadístico (incluyendo intervalos de confianza), la conclusión ha sido que A1 ha superado a A0 no sólo en la ejecución global sino también en la capacidad para alcanzar R en mayor número de ocasiones. Nuestro estudio confirma parcialmente los resultados acerca de la importancia de las intenciones de implementación en la Psicología Social.
Palabras clave: cognición social, intenciones de implementación, inteligencia artificial, simulación computacional.

An intention is a type of state of mind that regulates the transformation of motivational processes in volitional processes. Such transformation would be verified in two steps (Heckhausen & Kuhl, 1985): the first would consist in forming intentions while the second would appeal to the beginning of the action (see Figure 1). Recently, the intention concept has reappeared as a metacognitive instrument useful for the control of the actions. Gollwitzer (1993) distinguishes between goal intentions and implementation

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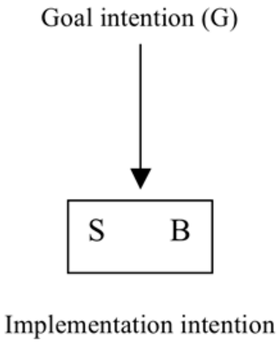

Figure 1. Implementation intention as a function of the goal G, the situational cue S and the behavior B.

intentions. To adequately context them, one must think that three levels exist in action thoughts (Gollwitzer & Schaal, 1998): (a) the level of the strategy or superior level, the one which defines the goals and states that the agent wishes; (b) the intermediate level of the operative planning, in which the subject is committed in a concrete behavior directed towards the goal and (c) the inferior level of the tactics, that consists of the execution of the behavior guided to the goal.

Goal intentions act in the strategic level while implementation intentions operate in the planning level. The first admit to be formulated through the expression "I intend to achieve X!" where X specifies a final wish state. On the other hand, implementation intentions can be stated as "I intend to do X when situation Y is encountered!" (Gollwitzer, 1996). This means that in an implementation intention, a future anticipated situation or situational cue is linked to a certain behavior directed to a goal; implementation intentions are subordinating goal intentions and they specify how to carry out the answers to reach the goal. In the accomplished investigations, implementation intentions have been shown as effective strategies of self-regulation in comparison with the strategies based on goal intentions. Thus, for example, in what is related to promote not nice actions such as the accomplishment of frequent medical reviews (Sheeran & Orbell, 2000) or in the daily intake of medicines (Sheeran & Orbell, 1999). At the same time, implementation intentions have demonstrated that they facilitate the actions directed to a goal in samples of critical populations, as in heroin addict patients under the abstinence syndrome (Brandstätter, Lengfelder, & Gollwitzer, 2001), schizophrenic patients or patients with injuries in the frontal lobe (Lengfelder & Gollwitzer, 2001). Implementation intentions act, since, as a powerful and flexible metacognitive instrument.

In implementation intentions, the agent passes, in good measure, the control of the action to a series of specified situational cues. The agent decides "in advance" what it will do and the conditions under those in which it will do it (Sheeran, Webb, & Gollwitzer, 2005); that is to say, in the measure in which the specified situations are found that act as support in guide towards the goal. In this article we accomplish a computer simulation comparing the behavior of two artificial agents: both simulate the fulfilments of implementation intentions, that allow to save obstacles and to be supported in critical situations which facilitate to achieve a final reward R; but while one of them will incarnate an agent A0 whose behavior is somewhat more capsized towards the goal intention of obtaining the goal R, the agent A1 will reflect a more planned behavior, that is, more guided towards the avoidance of obstacles and towards the utilization of the critical situations, for, at the same time, to attain the final objective R. The hypothesis to demonstrate will consist in, with a slight difference of the two agents' programming (related to a slightly different weight conferred to the search of R, to the search of the places L and to the avoidance of the sites S), the agent A1 will not only reach the goal R before A0 in a greater number of occasions, but its global yield, reflected in punctuation, will be superior. This is clearly in agreement with the results of Gollwitzer and collaborators, about the superiority of planning in humans the actions through implementation intentions front to the mere attempt of executing a goal intention to obtain an objective. To take into practice the simulation, an environment has been appealed, in the experimental domains line, typical of the Artificial Intelligence, as Wumpus World (Russell & Norvig, 1995) or Tileworld (Pollack & Ringuette, 1990). Therefore, we seek to support in artificial agents the conclusions to those which Gollwitzer and other investigators have come up with in humans. In fact, we apply to the agent A1 the same average efficiency percentage in execution of tasks, observed in human agents that have used the metacognitive instrument of implementation intentions, and we compare their yield with an agent A0. A0 is programmed to demonstrate a greater percentage than the average in human agents that use implementation intentions, which relates to the fulfilment of the goal. On the other hand, the percentages programmed in A0 which concern the accessibility of the situational cues, are inferior to the averages percentage registered in humans. These smaller percentages give place, at the same time, to an agent A0 less cautious than A1. A deterrent agent D0 behaves as an intelligent agent whose mission is to pursue and eliminate the agents A0 and A1, conferring a greater dynamism and a greater difficulty to the task. We begin exposing in-depth the ideas of Gollwitzer and other authors on goal intentions and implementation intentions.

Goal intentions specify the intention to achieve a goal while implementation intentions refer to the intention to execute a plan and they are at the service of the fulfilment of goal intentions. The diagrammatical representation of an implementation intention with its respective goal intention would be the following (with "G" representing the goal, "S" the situational cue and "B" the behavior directed towards the goal):

For example, the goal intention of eating healthily (G) would be linked to the behavior of requesting vegetarian food (B) in a restaurant (S) through an implementation intention.

Gollwitzer and Schaal (1998) have suggested that implementation intentions operate in the goals prosecution through three mechanisms. In the first place, such intentions permit a greater accessibility of the mental representations of the various situational cues, something that facilitates the detection of such supports in the environment.

A second mechanism suggests that implementation intentions introduce a twist in the attention processes. Thus, it would be assumed that a situational cue would draw the attention, even during the prosecution of other goals. After forming an implementation intention, the attention is attracted by good opportunities to act. Consequently, the attraction can be seen as a prerequisite so that the good opportunities to act are not lost and so that implementation intentions can develop their effects.

In third place, the training of an implementation intention links the situational cue to the specified behavior. In this way, the beginning of the behavior to the situational cue is delegated.

The force of the beneficial effects of implementation intentions depends on the presence or absence of various factors that act as presenters. In the first place, it seems that the effects of implementation intentions are felt more when the behavior directed towards the goal is more difficult to begin. Thus, according to Gollwitzer and Brandstätter (1997), implementation intentions are more effective when one must complete difficult tasks compared with easy tasks. In second place, implementation intentions do not seem to exercise effects when the respective goal intention is weak. Furthermore, Gollwitzer, Bayer, Steller and Bargh (2002) suggest that the beneficial effects of such intentions can be not observed when the respective goal intention has been abandoned. In third place, the effects of implementation intentions require the activation of the respective goal intention to the one which is found subordinates (Bayer, Jaudas, & Gollwitzer, 2002). In fourth place, the own force of implementation intentions also seems to count.

To end, the force of the mental link between the two components (the antecedent part and the consequent part) of an implementation intention also has to have beneficial effects (Gollwitzer, Fujita, & Oettingen, 2004). For example, in the case of a person who uses a lot of internal speech repeating the precedent and the consequent of the wrought plan by the intention.

Many times, the achievement of the goals on the behalf of the subjects is threatened by adverse situational contexts. Numerous situations have negative effects on the attainment of a goal. It seems that the self-regulatory strategy of planning the achievement of the goal, via implementation intentions, permits the people to obtain positive results without having to change the environment from one adverse to another more "grateful". This is something important, due to the difficulty of such types of interventions and also due to the inherent uncertainty to the environments variation. Endress (2001) found that implementation intentions ("And if I have found a solution, immediately I will attempt to find a different solution!") but not goal intentions ("I will try to find as many different solutions as possible!") protected the subjects to the effects of the social laziness.

Do implementation intentions have costs? This is something that Gollwitzer, Fujita and Oettingen (2004) have outlined very recently. In the first place, such intentions could carry to a rigid execution of many actions. In second place, the training if implementation intentions could result in a very difficult self-regulatory strategy. Finally, the authors ask themselves if such implementation intentions can have a rebound effect. With respect to the first issue, it is still considered an opened issue that implementation intentions can avoid the use of good alternative opportunities to be directed towards the goal, insisting on acting only when the critical specified situation is found in the antecedent of the implementation intention. Therefore referring to the second issue, implementation intentions delegate the control of the behavior to situational cues, in such a way that the self is not implicated. Thus since, the self is not seen exhausted by the use of this type of intentions.

What about possible rebound effects? In an experiment of Gollwitzer, Trotschel and Sumner (2002), the subjects had to suppress the stereotypes expression in a task of first impressions training, that was centred on a particular member of a stereotype group (in this case, homeless people). The rebound effect was measured in terms of the subsequent stereotypes expression in a labour that was demanding the evaluation, as a rule, from the people, or through a task of lexical decision that evaluated the accessibility of the stereotypes about homeless people. The individuals that only had the goal of controlling the stereotyped thoughts, while they formed an impression about homeless people, fell more in the stereotypes training and showed accessibility superior to them, than the participants that they had been invited to form implementation intentions. Truly, more than causing rebound effects, the implementation intentions seem to be effective in preventing them.

Design of a computer simulation for implementation intentions

We have elaborated a computer environment that proposes to compare the yield of an agent A0, that is also capable of taking advantage of situational help, but whose behavior is rather directed to the fulfilment of the goal intention of obtaining a reward R, with the yield of an agent A1, that pays more attention than A0 to the various implementation intentions (formulated using situational cues and obstacles to overcome). Our fundamental objective is to verify in artificial agents the effects of implementation intentions in the degree of goals attainment and in the general yield, adjusting the behavior of one of the artificial agents to the parameters observed in humans in the exhaustive meta-analytical study on the effects of implementation intentions, carried out by Gollwitzer and Sheeran (2006). When a simulation of these characteristics is accomplished, it is well known that it is possible to incur in two large types of mistakes that are necessary to avoid (Pidd, 2002): (a) the excessive simplification, that leads to a worked model with insufficient detail unable to handle the complete complexity of the simulated system; (b) the excessive elaboration, that generates a model that it incurs in a Type Zero mistake. Type Zero mistakes (Pidd, 2002) appear when the model is totally valid from a statistic point of view but turns out useless in practice because it centres in the wrong problems.

Our simulation avoids these types of mistakes. To carry it out, we have chosen a general purpose language as JAVA. In our simulation we will use the version J2SE 5.

We include in the simulation a 12×12 board and a marker of points, resetting, movements and of games. In the continuous perspective are indicated the total games, the total punctuation, the number of total resetting and the total victories of each agent. We have agents A0-A1, situational cues L0-L5, traps S0-S5, a deterrent agent D0 and a reward R. The objectives are as follow:

A0: (a) to achieve R; (b) to avoid to coincide or be swept by D0; (c) to provision points in L0-L5; (d) to avoid the traps S0-S5. The agent A0 starts with a positive punctuation, indicated in the paragraph related to the punctuations. A0 is only safe when home, located in the first top left square of the board.

A1: the same as those of the agent A0, but with a different level so much as in the fulfilment of the goal R as of the accessibility to the situational cues L and the avoiding of the traps S, which will reflect in the programming of the agent.

D0: (a) to intercept the agents A0 and A1. D0 begins by positioning itself near R and it seeks to eliminate the agents on the board, compelling then to reset it. The elimination of the agents A0-A1 is produced when the agents and D0 go towards the same square.

Movements:

A0-A1: they both leave their home advancing one square. But, from here, they can advance or recede 1 to 2 squares. They move North, South, East and West but never in diagonal. Each 25 accomplished movements, the traps S0-S5 are replaced (at random) on the board. This confers dynamism to the board and to the simulation. Replaced the board, the agents can fall on the same sites S in those which they fell on before. The agents "perceive" the proximity of every L, of every S, of D0 and of R. But in the case of the cues L, of the traps S and of the goal R, they are programmed to have a different degree of accessibility. If the agents A0 and A1 are intercepted by the agent D0, both lose points and they have to reset, keeping the same board. If any of the two agents were eliminated by D0 in more than five occasions, a new aleatory board would be generated, and would give a new start to the two agents.

D0: it moves just as the agents A0-A1 but it can only advance and recede from square to square. It appears in a random way on the low part of the board, near R, and it moves occupying the four last squares of the board, which makes him more effective in the persecution of the agents. Unless on home and on R, D0 can enter any other square of the board. It can invade any L or S place to eliminate the agents.

The payoffs for the agent A0 will be +50 points in the departure, +20 when A0 reaches L0-L5, -5 if A0 falls into the S0-S5, +150 when A0 achieves R, and -150 if A0 is intercepted by D0. If A0 is eliminated by D0, the board starts again, until a maximum of 5 rounds. On the fifth round the execution in the board finishes and begins on a new board. Finally, A0 is penalized with -1 point by each movement that is accomplished. Points assigned to the agent A1 will be +50 in the beginning, +25 when A1 reaches L0-L5, -5 if A1 falls into the S0-S5, +120 when A1 achieves the goal R, and -150 if A1 is intercepted by D0. If A1 is eliminated by D0 the conditions are as before. A1 is penalized with -1 point by each movement that is accomplished.

In the simulation, there is direction sensibility, that is, the agents know that the perceived items are to the North, South, West or East; the deterrent agent D0 possesses Artificial Intelligence and perceptions. Besides D0 intercepts the agents A0 or A1 only if they coincide on the same square. The execution ends when the agent arrives to R or when the fifth reset is produced. The agents move in parallel (it is a form of guaranteeing that the simulation conditions are the same by the randomness of the board; the agents always begin the same board in the same conditions together, see Figure 2). The general execution of the agents will be valued in function of (a) the percentage of times that an agent achieves R in first place or total victories, (b) the average points accumulated

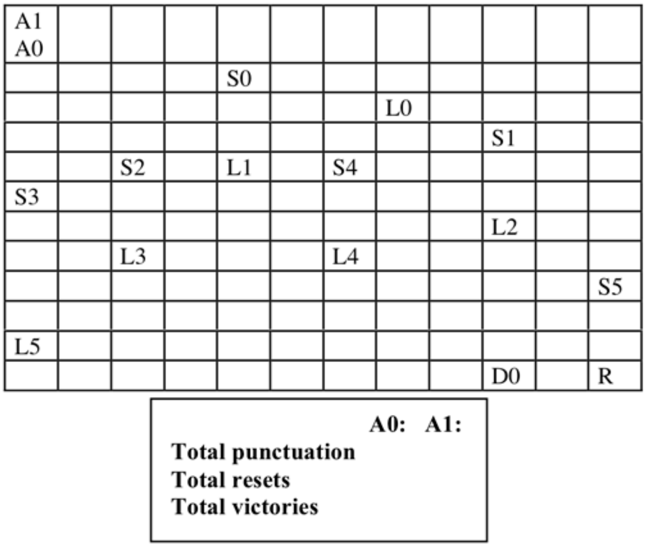

Figure 2. A representation of the Board including agents (A0-A1), situational cues (L0-L5), traps (S0-S5), deterrent agent (D0), and reward (R).

during the whole trials and (c) the average of resets. Perspectives of each agent have been added to clarify to the observer their movements. When they begin, the agents do not know where R is found and they look for it using Artificial Intelligence.

In a global sense, the simulation is dynamic and deterministic (the behavior of the agents is predictable, that is, each identical movement's cycle will generate the same number of steps). There is no learning adaptation in this simulation on the behalf of the agents nor a training style like the one carried in neural networks. In our case, we elaborate an *a priori* model specifying functions of probability distribution: We use for A1 an algorithm adjusted to three percentages of variance estimated by Gollwitzer and Sheeran (2006) as decisive in the average conduct of the human agents that are guided by implementation intentions for the fulfilment of a goal, and we vary those percentages for the agent A0 or the agent that is more guided towards the search of such goal.

Simulation parameters

Gollwitzer and Sheeran (2006) carry out a meta-analytical study of the effects exercised by the formulation of implementation intentions in the behavior of goals achievement on the behalf of the agents. We propose to move the fundamental parameters with humans to an agent A1 of implementation intentions and to compare results with an agent A0 somewhat more guided to the execution of the goal intention of reaching R. In our task, the goal intention can be formulated as "I intend to achieve R!", while implementation intentions are formulated as "I intend to do R when L is encountered!".

According to the authors, the general impact of implementation intentions on the goals achievement was of *d*= 0.65, based on *k*= 94 tests that implied to 8,461 subjects. This effect was highly meaningful and had a confidence interval of 95% from 0.60 to 0.70. The size of the effect is impressive because *d*= 0.65 represents the difference in the achievement of the goal generated by performing an intention with a respective implementation intention, compared with the training of a goal intention in itself. In this study, we do not compare an agent exclusively centred in the attaining of the goal intention, but we compare the behavior of two agents A0 and A1, both using implementation intentions for their achievement, but differentiating them in that A0 has a superior degree of goal attainment or, if needed, the execution of the goal intention, and on the other hand, A1 plans something more than A0, since the accessibility degree of A1 to the situational cues along with its percentage of the traps avoided is also superior. In fact, implementation intentions were proven to be beneficial to block adverse contextual influences. An important effect was obtained for implementation intentions when the goals attainment was blocked by adverse contextual influences (*d*= 0.93). Implementation intentions were also associated with the highly efficient processing of the situational cues. The size of the global effect for the processes related to the conditional component of the plan was large (*d*= 0.80). Concretely, the accessibility to the situational cues was of *d* =0.95.

In our simulation, we establish the following adjustment parameters that allow us to locate the percentages given to each agent and to accomplish the comparison. The agent A1 is going to represent an average human agent that benefits from the use of implementation intentions as the consigned results in the thorough meta-analytical study by Gollwitzer and Sheeran (2006). Thus, in our programming, 65% of the percentage will be assigned to A1 in the achievement of the goal, that is, a percentage of an average-large size. On the other hand, the degree of the goal attaining on the behalf of A0 will be large. Considering that we outweigh the respective achievements and failures by winning and losing points in the simulation, and that we seek a difference of behavior between A0 and A1 that allows to go from a percentage of average achievement of R to a large one, we locate a difference of 30 points in the attaining of R on the behalf of A0 of 16 percentage points: And so, A0 will have a degree of achievement of the goal R of 81%. Referring to the accessibility of the specified opportunities, this is very high in the agent A1 (95%) and considering that A1 can add 30 points more than A0, taking advantage of the situational cues, what happens is that we will assign A0 an average-high percentage utilization, in this case, of 76%. Considering that the degree of avoiding traps on the behalf of A1, as corresponds to an agent that is supported in implementation intentions, is very high (93%), to A0, that plans less than A1 and that goes more blindly, we also assign it a difference of 19 points, that is to say, of 74%, that is also an average-high percentage and is interrelated with the previous. Nevertheless, to fall in any S places counts equal to the penalization effects for both agents. We plan the comparison between the three types of fundamental parameters in Table 1.

Table 1. Percentages of the Three Types of Parameters of the Simulation.

A0	Achievement R (81%)	Accessibility L (76%)	Avoiding S (74%)
A1	Achievement R (65%)	Accessibility L (95%)	Avoiding S (93%)

Results and discussion

We take into account the empirical results, once accomplished 5,000 games, with an average of about 48 movements a test. We have chosen this number of games, in agreement with other experiments as, for example, that of (Kinny & Georgeff, 1991), that accomplishes 25 tests with an average of 10,000 movements in each test. We insert the percentages and total results in Table 2.

As can be observed, the data of the simulation support the thesis of the fact that even an agent A1, programmed to reach a goal R with a smaller degree of fulfilment than an agent A0, but with more planning, is capable of obtaining R in the first place, even in a greater number of occasions. Considering the importance that Gollwitzer concedes to the maximum utilization on the behalf of the situational cues for the goals achievement, as well as that the agent A1 is programmed to respect the fundamental parameters observed by Gollwitzer and other authors in human agents that use implementation intentions, we believe that these results suppose an accolade for the key thesis of the German author: implementation intentions permit a superior global yield therefore referred to goals achievement on the behalf of the subjects. Even between two agents, as those of our simulation that appeal to the critical cues propitiated by

Table 2. Final Results of the Simulation.

	A0	A1
Number of games	5,000	5,000
Total points	981,131	1,001,503
(Average)	(196.22)	(200.30)
Total resets	2,261	2,261
(Average)	(0.45)	(0.45)
Total victories	2,438	2,562
(%)	(48.76)	(51.24)
Number of L places	23,850	26,800
(%)	(47.08)	(52.92)
(Average)	(4.77)	(5.36)
Number of S places	13,888/20,800(Total)	12,048/12,550(Total)
(%)	(53.54)	(46.46)
(Average)	(2.77)/(4.16 Total)	(2.40)/(2.51 Total)
Number of effected movements	233,700	249,550
(Average)	(46.74)	(49.91)

implementation intentions, the one which centres its behavior more in the fulfilment of the goal intention of arriving to the goal R (in our case, the agent A0), comparatively ends up worse in all the statistic aspects. But let's analyze with some thoroughness our data. In the first place, it is appreciated that the average points obtained by A1 slightly beat the average points obtained by A0 (200.30 compared to 196.22). This is something that we should not surprise us since, even in spite of the fact that A0 has been assigned a remuneration of 150 points by achieving R compared to the 120 points assigned to A1, the difference of punctuation is compensated with the maximum number of points, originating from the L cues, that can accumulate A1 (150) compared to the 120 of A0; if we observe the average critical situations L to those which accedes A0 in each game, this is of 4.77, what supposes average accrued points of 95.40 in each trial.

On the other hand, the average L places to those which A1 has access to is of 5.36, which supposes an average accumulation of 134 points, that is, an average accrued difference with respect to A0 of 38.60 (95% of confidence interval for the number of places L, results statistically meaningful and is located between 6,583.34 and 44,066.65). But also a difference is given concerning the avoidance of the traps S: without taking into account those places S repeated in those which both agents return to fall on once the board has repositioned every 25 movements, A0 falls in average, in 2.77 S places, while A1 falls in an average of 2.40 traps by game, or rather, an average difference of 0.37 (in the total, A0 falls on repeated S, quite more than A1; 1.39 of average as compared to 0.11). This means that as compared to an average penalization of 13.85 points for A0, A1 receives an average penalization of 12 points. The confidence interval for the number of S places (without repeating) in those which A0 and A1 fall on results statistically meaningful (between 1,278.29 and 24,657.70). Therefore, even if it is true that in the achievement of R, A0 has an advantage of +30 points, this advantage would remain neutralized by a possible average accumulation of +40, 45 points on the behalf of A1.

Nevertheless, the notable decrease in the difference of percentages that relate to L places (19 points in our programming as compared to the almost 6 reflected in the simulation in favour to A1) and to the S places (again, 19 points, as compared to 7 minor avoiding points in A0), with respect to our percentages initially programmed, this should carry us to reflect. In reality, so much as the access to the situational cues L as to the traps S, can result a process a lot more complex than what, apparently, would seem. It would have to do more with all the planning process followed by an agent than with a directly mere pre-programmed plan. This result gives us a great lesson: the whole finishes emerging from the parts. Or expressed otherwise: the diversity of tasks that the agents have to execute on the board (reach R, seek the L places, escape from the agent D0 and to avoid to fall on the S places), ends up interacting in a dynamic and meaningful way. This is appreciated with greater power in which maybe will be the most decisive and surprising result of this simulation exercise: in which the most planning agent, A1, achieves the goal R in a percentage greater than A0, when A0 has been programmed to perceive and accede to R with greater solvency and facility. Without taking into account any other type of interaction with any of the other tasks of the game, what is certain is that the difference of 16 points in favour of A0 in the programming to reach the goal, should propitiate that, for each 50 times that A0 arrived first to the goal, A1 would have only arrived in 40 occasions. And, however, A1 arrives to R more times first in percentage, 2.48 points in favour of A1. Furthermore, the confidence interval of 95% is statistically meaningful and is located between 1,712.21 and 3,287.78 victories. How can this result be interpreted? Very probably, that the most planning agent, A1, continues following the cues L and, at the same time, avoiding the traps S, with greater solvency than the agent A0, which enables him, in middle to long term, to obtain the final objective before; that is to say, not only is its global yield going to be superior (something easily foreseeable) but its commitment with the achievement of the goal, finishes also being superior. In fact, these results would be saying that Gollwitzer (1996) was right when he reaffirms the positive effects of implementation intentions: these tend to create a series of situational links that generate an efficient response in the goals achievement. The most capsized agents to planning and situational cues utilization in the goals implementation in fact process the information more effectively and therefore are less tending to the distraction and to the irrelevant information, that is, they are more cautious and less careless falling into smaller number of traps. They sequence the actions to accomplish and process better.

As Gollwitzer, Bayer and McCulloch (2005) insist, the cold cognitive strategy of guiding the attention sequentially, typical of an A1 agent, contrasts with the hot strategy of determined effort mobilization, for example, towards the achievement of the goal. Therefore, to obtain an optimum yield, it is considered to form implementation intentions that are centered in ignoring distractions towards the goal, processing in an effective way the situational cues and avoiding traps. Consequently, the key is not in strengthening the effort directed to the goal. It has been verified with experiments (Gollwitzer, Bayer, & McCulloch, 2005) that the staying away by means of implementation intentions ("And if a distraction emerges, then I will ignore it!") are more effective than implementation intentions than are outlined as making easier the achievement of the goal or of the execution of the goal intention ("And if a distraction emerges, then I will increase my effort towards the task!"). In some way, the super motivation to crystallize the simple achievement intention of a goal, would result prejudicial in humans and would worsen the intentional execution. Curiously also, that super motivation that carries A0 to assume more risks in its prosecution of R, is balanced, till a certain point, with the more planning character of A1 (an average of 49.91 movements by game as compared to 46.74 of A0): furthermore it occurs that the confidence interval for the number of movements effected by the two agents, is statistically meaningful (from 140,928.33 to 342,321.67). Both agents coincide with their average of resets, that is, in the average times that they are eliminated by the deterrent agent D0, what is not statistically meaningful, but yes could be understood that it would compensate the greater trend of A0 to risk, with the superior trend of A1 to plan and, consequently, to concede to D0 the opportunity of eliminating it.

We can affirm that, on a whole, all these series of results, would explain that A0, yet being more inclined to obtain the goal, results less effective than A1 and even arrives a less number of first times to obtain R. From here it can be culled, therefore, the principal corollary of this simulation exercise: even counting on obvious limitations in a design of these characteristics, the primary idea of Gollwitzer and collaborative in their experiments on humans (the greatest efficiency of the use of implementation intentions to achieve goals), would be seen confirmed in the area of the Artificial Intelligence.

We have accomplished in this task a simulation that has compared the behavior of two different agents: an agent A0 that has taken advantage of the typical situational cues of implementation intentions, but whose direction towards the goal of the reward R has been high; on the other hand, its planning level, countersigned in the situational cues supports utilization and in the avoidance of traps, has been inferior to that of an agent A1. Our test method has consisted of accomplishing 5,000 trials on 5,000 different aleatory generated boards.

We believe that our simulation has fulfilled the basic objective of supporting, in the area of the Artificial Intelligence, the experimental conclusions with humans, of Gollwitzer and his collaborators, about the superiority of the use of implementation intentions in the objectives achievement, against the emphasis located in the execution of goal intentions.

As an obvious result, this task, given its limited nature, has not collected all the possibilities. Thus, the issue of the beginning of goal purpose has not been approached, since the two agents have to forcibly begin it and in equal conditions. According to (Gollwitzer, Fujita, & Oettingen, 2004), the effects of implementation intentions are more apparent when more difficult it is to begin the behavior directed towards the goal. Neither has the issue of the fact that the agents abandon the purpose of achieving R or that they seek alternative goals been outlined. For example, in the application of an implementation intention by a human agent, not always to accomplish physical exercise you have to count on the availability of the fact that the elevator is broken, which would avoid its originating implementation intention or maybe would carry him to put an alternative implementation intention in practice, that could emerge through a new situational cue; the fulfilment of the goal intention of doing exercise, for the one which to get the consequent implementation intention, would be somehow seen affected. On the other hand, not even the effect on the learning of the task as consequence of successive frustrations has been outlined (in our simulation, for example, the effects of various resets on the behavior of the agents). It would be interesting, to introduce agents not only based on learning rules but also adaptive agents.

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