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RESEARCH ARTICLE

A View on the Determenistic Explanation of Actions Based on the Joint Construction of Goals and Means

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ABSTRACT

People describe and explain everyday behavior and cognition in terms of actions, that are goal-directed processes. There are two conventional approaches explaining the construction of goal-directed processes (predetermined goals and means and the separate and arbitrary construction of goals and means). However, these approaches cannot elucidate the flexibility and diversity of actions and some characteristics of thinking. We hypothesize the goal and means of an action are constructed jointly on the basis of the criterion of minimal construction costs and this entirely determines actions. Some ideas in favor of this mechanistic explanation of actions and objections against it are considered. The idea that the mechanism of joint construction entirely determines actions was examined in an experiment when participants were informed on the joint construction mechanism and instructed to violate its functioning by performing an action. Participants could violate the functioning of the mechanism at two levels of the action but information about one level was more explicit than about another level. It was assumed that participants would violate the functioning of the mechanism only at one level. This means that joint construction really determines actions because a sort of compliance between these levels was necessary to perform the action. This assumption was confirmed experimentally.

Keywords: action, goal, means, goal-directed

1. Introduction

If one asks a common person on her current activity then answers can be as follows: 'I'm driving my car to arrive to work on time" or 'I'm thinking about my future vacation' or I'm trying to sleep because I have to get up early tomorrow". Indeed, people describe and understand their everyday life in terms of actions. Actions are considered to be voluntary processes directed at the achievement of goals that are future observable or mental states. It is reasonable to assume that the causation of actions should be the basis for a discipline that tries to explain and predict behavior and cognition. However, actions are very various and flexible and individuals continuously monitor their own ongoing actions and change them via feedback loops. Moreover, psychological functions can deliberately be adjusted for achieving future results. These characteristics make the understanding and prediction of actions extraordinarily difficult.

Since the origin of psychology another way has been preferable for the explanation of behavior and cognition. This way which can be designated as bottom-up, posits that cognition and behavior can be considered the results of the functioning of some autonomous, goal-independent systems such as perception, attention, emotions or metacognition. The bottom-up way suggests to restrict maximally the complexity and diversity of the actions of participants in experiments thus making their behavior similar to processes that are studied in natural sciences. Indeed, in psychological laboratories participants have to press one button among several ones or to select a response among several responses to a statement of the questionnaire. Participants usually are not familiar with the true objective of the experimentation and sometimes the experimenter deliberately deceives participants[1].

It is suggested this way allows revealing some simple mechanisms of behavior and cognition that function regardless of purposefulness and deliberation. The final objective of the bottom-up way is to collect a sufficient basis of the simple mechanisms to elucidate actions mechanistically.

The assumption that the bottom-up way allows determining the simple mechanisms unequivocally is taken for granted, probably because the idea of restrictions on the behavior of participants is borrowed from natural sciences where researchers successfully minimize the effects of superfluous variables. However, the causation of mental processes is absolutely different from the causation of physical and chemical ones. Indeed, if the complexity of behavior is reduced in experiments, this does not mean that goals do not influence behavior because the participation in an experiment is always some sort of action. Everyday experience demonstrates small variations in goals may strongly influence behavior, therefore a slight change in the experimental situation may considerably affect the purposes of participants which, in turn, may alter their behavior. Such alterations can be unconscious. If it is impossible to eliminate the effects of purposefulness and deliberation, then different results may be obtained in experiments where experimental conditions seem similar, but the goals of participants are distinct. This may be one of the reasons of the replication crisis[2]. Another consequence is stagnation in many psychological disciplines because experimental data may not allow defining the correct theory among possible competitors.

In April 2018 one of the authors got a letter (the author did not request it) from the journal "Cognitive Psychology" offering to take a look at the most downloaded articles from this journal in the last 90 days. The list included 25 articles published from 1972 to 2018. Since this list is obviously outdated we also looked at a similar list from September 2023. The 2023 list includes eight publications only therefore, it is not so representative, however both lists demonstrate a similar trend. Two distributions of the most downloaded publications by the decade of publication are presented in Figure 1.

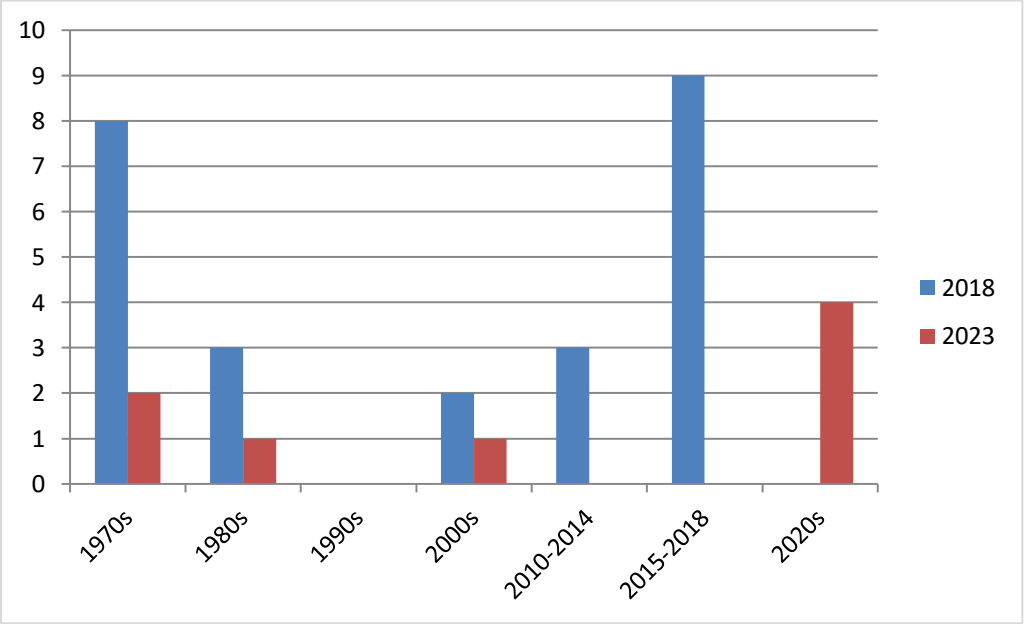

Figure 1. Distributions of the most downloaded publications in "Cognitive Psychology"

Many of the articles were published in the 1970s. The number of the articles published after the 1970s tends to decrease and there are no articles published in the 1990s at all. The 2018 list includes 12 articles that were published in the 2010s. This may indicate a change in trending. However, these articles were novel at that time therefore many scientists could be in the process of familiarizing with it yet. To examine these two hypotheses we divided these 12 articles in two groups regarding the year of publication. If there was something like a scientific revolution in the 2010s then the size of the groups may be similar. However, if the 2018 list simply reflects the novelty of the articles published in the 2010s then the second group may include more publications because these publications were newer in 2018. The diagram obviously corresponds to the second hypothesis. In addition, the 2023 list does not include articles being published in the 2010s. It is reasonable to assume that the four papers that were published in the 2020s are downloaded frequently due to its novelty.

A large number of the most downloaded articles that were published in the 1970s reflects changes in psychological science denoted as the cognitive revolution. For several decades behaviorism dominated in psychology and studies on cognition were neglected. Only in the 1960s research on cognition became intensive and in the 1970s cognitive science surpassed behaviorism as a

main psychological paradigm. It seems that the papers published in the 1970s became ground-breaking because at that time their authors were, to some extent, pioneers exploring a new land when every step may lead to discoveries. It is reasonable to suggest that a small number of ground-breaking articles published after the 1970s means that since then cognitive psychologists have not been successful in understanding cognition.

Of course, some researchers realize that goals determine behavior and cognition, therefore psychological research cannot be reduced to the exploration of simple mechanisms. As a result, there are theories that attempt to explain cognition and behavior in terms of goal-directed processes[3-5]. This way can be designated as top-down. The top-down theories do not propose a deterministic explanation for the construction of actions, they simply criticize the down-up way mentioning that the down-up way is insufficient to explain the complexity and adaptability of actions. To understand the causation of actions the top-down theories suggest to study actions of particular individuals in situations when behavior is not retricted[3-4]. However, the results of such studies can hardly be generalized therefore, the top-down theories cannot compete with the bottom-up ones which are sometimes capable of predicting the behavior of many people. No wonder, the top-down theories occupy a very limited niche in psychology.

It is reasonable to assume that the top-down theories could be competitive with the bottom-up ones only if such theories would propose a mechanistic explanation for actions that allows predicting behavior and cognition effectively. On the other hand, such a hypothetical mechanism should not restrict the complexity and variability of actions. We present a hypothesis that meets such requirements below. Also, an experiment confirming the hypothesis is described.

2. Two approaches to the construction of actions

We posit the mind is an active system and most aspects of behavior and cognition can be considered the results of actions. Actions are generally presented in terms of goals and means. A goal is a resultant state that the individual achieves or leaves unchanged (a goal is usually considered a conscious representation of the future result, however henceforth we suggest that a goal is any representation of the future result, conscious as well as unconscious). A means is characterized by various methods that permit goal achievement. Using this terminology, an action can be defined as a process directed at the achievement of a certain goal through interactions with the environment based on diverse means. Key questions to ask are: How are goals and means constructed? And what is the relation between them?

There are two fundamental approaches to these questions that are based on scientific research and everyday experience. One approach proposes that, like other animals, humans have a complex structure of innate, predetermined goals and means associated with survival and reproduction. According to this approach, human actions result from an activation of one or several innate goals and means or from the functioning of learned goals and means, which are constructed on the basis of innate ones through feedback loops. For example, behaviorism suggested an innate motivation mechanism to establish

connections between goals and means through reward and punishment[6]. Currently, evolutionary psychology very explicitly proposes that humans have an innate repertoire of goals and domain-specific modules[7-8]. Automatic actions such as habits can also be attributed to this approach because the result and the method of such an action were being constructed together and regardless of the ongoing situation. However, this approach is unable to explain the diversity and rapid alterations of actions, either at the level of a single individual or of a whole society[9].

Our experience tells us that one goal can be achieved through various means. Moreover, one means can be applied to achieve different goals. These facts are the basis for the second approach that suggests humans arbitrarily and separately construct goals and means. This approach underlies a naive view on goal-directed processes as various theories of goal-directed behavior as well[10-11]. Because the approach is used in all domains of everyday practice, it seems to be absolutely correct. However, a more profound view on the approach demonstrates its certain weakness. Indeed, once a goal is set up, it is necessary to search or select an appropriate means to achieve it. In any situation the number of means that can potentially be retrieved from long-term memory or elicited by the situation is huge. For example, if an individual is hungry, she has an option not only to open her fridge but also to have breakfast with any neighbors, or to go to any restaurant, or to steal groceries from any supermarket, etc.

Any possible action itself results in a new diversity of options. For example, there may be many routes to the restaurant selected and there are many options to get to the restaurant (on foot, by bike, by car, by public transport, etc.). As a result, searching among possible means can be unrealistically long and expensive. This is a problem of a "combinatorial explosion" of options in Artificial Intelligence that was realized by researchers in the 1950s when the first artificial intelligence programs were designed but the solution has not yet been found[12].

However, people regularly make effective and flexible decisions without being overwhelmed by their decision-making processes. One may suggest that searching among optional means takes place at an unconscious level and because human cognitive capacity is limited, only few possible means are involved in searching and matching the goal. As a result, the combinatorial explosion does not occur. If this idea would be correct, thinking should be efficient in experimental situations when the number of available means is limited, yet, numerous experiments demonstrate that in such situations thinking can be remarkably inefficient[13-14].

Some researchers propose that emotions[15-16], "gut feelings"[17] or innate heuristics[18] are sufficient to constrain the combinatorial explosion. Emotions, of course, impose strong constraints on actions, however, each layperson concurs that these constraints usually are coarse and rigid, hardly effective in many situations. Moreover, emotions obviously include innate components. Therefore, if emotions and innate heuristics are the main mechanism for the construction and selection of actions, then human actions, in general, are innate.

Everyday experience demonstrates that people seldom search deliberately among possible alternatives. Instead, they often construct actions fast and intuitively. In accordance with such observations, the dual-process models[19-20] propose the mind includes two systems. One

system, often being designated as System 1, is automatic, fast, and associative. System 2 is deliberate, rational, and reflective. The dual-process models suggest that in most everyday situations System 1 automatically selects an appropriate goal and a means on the basis of past experience. Only in rare cases when System 1 fails, System 2 is activated and provides conscious search among alternative means. These models face two challenges. First, the suggestion that most actions are performed by automatic and associative System 1, is hardly consistent with the general arbitrariness and purposefulness of actions. Indeed, automatic actions that are based on the schemes of past experience only and therefore inconsistent with the ongoing context is one of the features of prefrontal patients[21]. Second, if there are two systems of thinking then under specific circumstances when it is reasonable to expect the activation of System 1 only (for example, under time pressure) the process of thinking should be qualitatively different from other situations. However, this assumption is inconsistent with experimental data[22-23].

The analysis of the conventional theories of the formation of actions demonstrates that these theories cannot explain the flexibility and purposefulness of actions and some characteristics of thinking. We suggest that the standard view on the possible approaches to the construction of goals and means is incomplete, therefore a more complex formal categorization is considered below. This classification is used to introduce a novel hypothesis regarding the construction of goal-directed processes.

3. The hypothesis of the joint construction of a goal and a means

The two basic approaches to the construction of actions are usually considered two poles of one axis ("automatic" versus "deliberate" or "instinct" versus "intelligence") and as a result, it seems that there are no other approaches. However, a formal view on the basic approaches demonstrates that the situation may be more complex. Indeed, the first approach suggests that basic goals and means are constructed innately and together. The second approach proposes that goals and means can be constructed arbitrarily and separately from each other. It is easy to discern that the words "innately" and "separately" are not antonyms, neither are the words "together" and "arbitrarily." From a formal position, the two approaches are a part of a two-dimensional structure, in which one dimension can be characterized as "innate" or "predetermined" versus "arbitrary" or "learned" and the other dimension as "together" versus "separately." With this assumption, a representation of this structure is given in the following table.

Table 1. Possible relations between goals and means.

	Together	Separately
Innately (predetermined)	Goals and means are constructed innately and together	Goals and means are constructed innately and separately
Arbitrarily (learned)	Goals and means are constructed arbitrarily and together	Goals and means are constructed arbitrarily and separately

It is easy to see that two cells in the table correspond to the conventional approaches but two new approaches emerge from the other cells. One new formal approach suggests that goals and means can be constructed innately and separately. This is, however, logically impossible. Indeed, if basic goals and means are formed at the moment of the construction of a goal-directed system then these basic goals and means share some common components of the system, therefore, goals and means, in general, cannot be constructed separately.

The other new approach is that goals and means can be constructed arbitrarily and jointly. If one suggests that the construction of goals and means is based on the idea that the costs of this process should be minimal, then some formal advantages of this approach can be easily demonstrated. Indeed, because goals and means are constructed jointly, there is no need to search among a potentially infinite set of means to satisfy a given goal. This is a simple solution to the problem of the combinatorial explosion. On the other hand, the possibility of constructing goals and means arbitrarily indicates that constructed actions may be very flexible and adaptive.

Given these advantages, we suggest that the idea of a joint construction of goals and means can be very useful for understanding the construction of actions. As is mention above, we posit that human actions are goal-directed processes: the goal of such a process is a situation or a state that the organism should achieve in the future. Functional operations are considered means. A means having cognitive, emotional, and motor components can be rapid and unconscious or can correspond to a sequence of conscious actions. The goal and the means comprise a method by virtue of which the individual is able to meet the requirements of the situation (henceforth, the term "situation" means all ongoing internal and external influences on the mind). We hypothesize that the goal and means of a goal-directed process are constructed together and anew from the interplay between the situation and the hierarchy of the ongoing goal-directed processes. The construction is self-organizing and the criterion for self-organization is to minimize the costs needed to construct the goal and the means[24-25].

The criterion of minimal construction costs can be considered the transfer from physics to cognitive science the fundamental principle of least action. In physics, the trajectory of an object is derived by finding the path which minimizes the action (in physics, a quantity that is associated with the energy of the object)[26]. It is important to note that the criterion of minimal construction costs is an internal criterion therefore the goal and the means that are constructed on the basis of the criterion may be not effective from the position of external criteria that determines relations between the individual and the environment.

The idea of self-organization suggests that goals and means are constructed from the interactions among some elementary entities. The assumption that the interactions among elementary entities underlie cognitive processes is widespread in cognitive science. For instance, connectionist units[27] or rules in the ACT-R theory[28] are examples of elementary entities. Connectionist nodes are borrowed from neuroscience and ACT-R rules were found in logic. Obviously, that connectionist nodes do not describe the full diversity of neural data and ACT-R rules do not exhaust mathematical

logic. Therefore, other elementary entities are possible. A model for the joint construction of a goal and a means based on the interactions among entities that are not connectionist units or ACT-R rules is presented elsewhere[24].

The idea that a goal and a means are constructed jointly is based on the strong evidence that the prefrontal cortex that is responsible for goal-directed behavior does not process goals and means separately[29-30].

Joint construction is absolutely unconscious and uncontrollable, but it results in the conscious representation of the situation and the individual, that is, the person acknowledges what goals and results can be achieved in the situation, how this can be performed, what criteria can be used to evaluate these goals and means. In other words, joint construction constructs simultaneously not only the representation of the external world but also the representation of the individual herself or himself. Because any human action is a hierarchical multilevel process some levels of the process are in the focus of consciousness and other levels comprise the background.

In order to clear the functioning of joint construction, consider again a hungry individual. If she is hungry she may recall some grocery shops and some information on these grocery shops: routes to it, its prices and some emotional attitudes regarding the shops. This is an absolutely unconscious joint construction process that results in a coherent representation of the situation and this representation may be appropriate for the satisfaction of the ongoing need. The world is infinitely complex therefore this representation is one among potentially possible others only and it may not be optimal (for example, a grocery shop with minimal prices is not recalled) however, this is the solution for the problem of the "combinatorial explosion" of options. The construction of the model of the current situation is a primary function of joint construction. In principle, one grocery store may be recalled and then the person may decide to go to this store. When she leaves her home a new joint construction process occurs that results in a new model of the situation when the objects of the environment that may be appropriate for achieving the store become perceptible.

If several grocery stores are recalled then its comparisons and the selection of the best store are necessary. From the position of the joint construction hypothesis (referred to as JCH hereinafter), these actions are secondary goal-directed processes because those are performed within the primary model of the situation. The consequence of such actions can be the awareness of the failure of the primary model and then a new primary model can be emerged. In other words, feedback loops from interactions between the individual and the environment lead to the construction of novel goal-directed processes however, since practically any action is multilevel, changes at lower levels of a goal-directed process are possible without changing at its upper levels.

It is very important to emphasize that JCH does not suggest the existence of an internal "observer" who watches ongoing actions and activates or inhibits the mechanism of joint construction when necessary. The joint construction hypothesis posits that joint construction entirely determines mental processes including the feeling of agency.

From the position of JCH, the effects that are discovered in laboratory settings are components

of the actions that can be constructed with minimal costs in these settings. These effects can be replicated in other settings if the cost of its construction is also minimal otherwise these effects are not replicated. However, JCH does not suggest that all aspects of cognition and behavior can be modified. There are limitations associated with individual characteristics (for example, general mental ability), maturation, aging, diseases. In terms of JCH, some factors of mental functioning always contribute to the construction of actions with minimal construction costs.

The joint construction hypothesis is a unified approach being able simply and parsimoniously to explain various phenomena of cognition and behavior. For example, because joint construction is always performed anew and on the basis of minimal construction costs, JCH explains why decision-making is susceptible to priming[31-32] and depends on the format of the situation[33]. Joint construction underlies riddles and puzzles when an individual cannot solve a simple problem, although his or her knowledge and skills are extremely sufficient to do this[34].

One may propose some objections to JCH. First, if a goal and a means are constructed together then the means ought to be appropriate for achieving the goal. However, people often understand what goal must be achieved but they cannot suggest appropriate methods to achieve the goal. For example, one of the authors would like to be a winged dragon roaming between stars but he has no idea on how to be converted into such a dragon.

However, a person can dream to become a dragon only if she preliminary selected information on dragons from the infinite variety of information on the world. In other words, the dream of converting in a dragon is a secondary process within such a representation of the world in which there may be dragons. This representation is the result of a primary joint construction process. As is mentioned above, joint construction is not the method to create the best action (this is impossible due to the combinatorial explosion) but the method to create some action (because the number of possible actions is infinite, in principle). To some degree, an alternative to the action which is formed by the ongoing joint construction process, is not another action but rather its absence. Therefore, JCH is not hurt by the fact that people are able to imagine or pursue completely arbitrary even unachievable goals. Because even when the individual thinks that there is no method to achieve the goal, nevertheless an inappropriate method is chosen because the selection of a specific aspect of reality among the infinite number of other possible aspects occurred.

Second, experience demonstrates that one goal can be achieved by various methods and that one method can be applied to achieve various goals. These obvious facts, which underlie one of the two conventional approaches, seem inconsistent with JCH. We suggest that the idea that goals and means can be constructed separately is correct at the level of social practice but a psychological illusion at the level of psychological mechanisms of a particular action.

In order to clear this idea, imagine that one needs to achieve the 35th floor of a skyscraper. Firstly, this can be made by means of an elevator. If no elevator can be used (e. g. there is no voltage), it is possible to go upstairs. Finally, if the staircase is destroyed then one

can climb on the wall using necessary tools. It seems one invariable goal can be combined with various means to achieve it. However, the first means is available for everyone because it requires no concentration of mental resources. The second one can be accepted when there is a serious need to achieve the goal. The last one can be used only under extreme circumstances requiring the strongest concentration of will and energy. In other words, from the position of internal processes each way requires a certain psychological arrangement with special goals and this arrangement is acknowledged by any individual as distinctive from the others. Therefore, a change in the situation results in the alteration of goals and means at a particular level of the hierarchy of goals. It is reasonable to assume that the interaction between goals and means in the process of the construction of a goal-directed activity is a characteristic of any such activity.

Like other psychological illusions, such as the illusion of the instantaneous reaction to an external stimulus (the understanding that the reaction is not instant, occurred in 1823 only[35]), the illusion of the separate construction of goals and means results from the fact that it is very difficult to combine the involvement in a particular activity with the simultaneous introspective monitoring of this activity. Indeed, when an individual pursues a particular everyday goal (e. g., shopping at the supermarket) she usually does not pay attention to all variations in the intermediate goals and means that are necessary for this multi-stage pursuit. As a result, the complex interplay of these intermediate processes is reflected by consciousness and memory only partially, while success or failure in the achievement of the main goal is usually in the focus of consciousness.

A skeptic may say that the criterion of minimal construction costs is trivial because practically all theories in cognitive science implicitly or explicitly assume that actions are selected in accordance with a minimal or maximal criterion. For example, some models suggest that people choose the easiest way to perform an action[14,36] or that people prefer actions with maximal utilities[37]. Some authors assume humans are cognitive misers[14,20,38]. However, such criteria define the use of objects within the model of the ongoing situation, that is people select the action with a maximal utility among several actions that are currently conscious. The criterion of minimal construction costs characterizes the construction of the conscious actions. It is possible to say that JCH describes another level of mental functioning as compared to the conventional models.

One may declare that it is not easy to use JCH for explaining and predicting a particular action. According to JCH, to understand what goal and means can be constructed in a situation it is necessary to reveal all factors that can be involved in the construction and to minimize the cost of interactions between them. This is a complex process that may require the use of computer models. Yet, we believe the joint construction hypothesis is the necessary condition for advances in understanding actions because the hypothesis suggests the deterministic explanation for the construction of actions.

4. Experiment

The hypothesis of joint construction explains the purposefulness and flexibility of human actions and how the mind overcomes the combinatorial explosion of options. We suggest this is sufficient to suggest that JCH is a correct hypothesis. However, a skeptic can say

that more rigorous experimentation in which the relationship between cause and effect would be unequivocal, is necessary to confirm JCH. A fundamental problem regarding the examination of JCH is that in an experimental situation when the activity of participants is contained, joint construction is "frozen", therefore an alternative explanation of the result of the experimentation in terms of simple mechanisms can be suggested. Therefore, the explanation of the result on the basis of JCH may seem too complicated and unnecessary.

For example, it is of interest to examine the basic idea of JCH is that a goal and a means are constructed jointly. Imagine an experiment when a participant reads the short description of a person and is instructed to respond whether she invites this person to a party. Moreover, the participant is instructed to select some possible characteristics of the person from the list. Let us imagine that that the description of a person hints that the person is a former criminal. In this case, participants probably prefer to avoid the person and also to select some negative characteristics from the list. A proponent of JCH can say such results mean the goal of the action, that is the choice of the response is emerged along with the means that is justified the choice. A skeptic may say that the responses of participants are determined by past experience and standard social attitudes. Yet, social attitudes do not explain why people can invite a former criminal, if necessary.

To weaken the problem of alternative explanations it is necessary maximum to "activate" the joint construction process however, keeping rigorous experimental conditions. The experiment described below attempts to meet such requirements. The joint construction approach assumes that joint construction entirely determines actions. This assumption can be confirmed only if individuals are not able to influence this mechanism intentionally.

One method of examining this assumption is to inform participants on JCH and to offer participants to violate the principle intentionally. If this is possible, then a basic mechanism of actions is distinguished from joint construction because this mechanism supervises the latter. Obviously, the actions of participants can be flexible in such an experiment.

The given experiment is based on the fact that any action is a multilevel process. In the beginning of the experiment, participants were informed about the rule of minimal costs. Afterward, they were instructed to breach the rule by performing an action. Participants could violate the rule of minimal construction costs at two levels of the action, but information about one level was more explicit than about another level. As a result, it was assumed that participants would violate the rule only at one level, although both levels were necessary to perform the action. This means that joint construction is the only mechanism underlying actions, because all levels of an action are necessary to perform it and there should be a sort of compliance between these levels. Participants really did not violate the mechanism of joint construction; simply, in the unusual conditions of the experiment, joint construction may brought about special results.

4.1 Materials and Methods

Participants. A total of 55 (M age=35.1 (17-72), 41 females) participants took part in the experimentation. The experiment was conducted on-line and the participants were recruited on a crowdsourcing system. The participants were paid US$0.8 for their work. The experiment

followed the principles of the Declaration of Helsinki.

Design. There were three pages of complex instructions (see below). First, a participant was familiarized with the rule of minimal costs, which was illustrated by several pairs of images. The images in a pair corresponded to two opposite categories (for example, "beautiful" versus "terrible"). There were three pairs of images in the descriptive part of the instructions, and in the third pair, one image directly associated the left button of the mouse with a standard mode of action. The second image associated the right button with an unusual mode of action. (See Instruction section.)

Afterward, the participant was informed that new pairs of images from opposite categories should be presented. The target was to select an image in each pair, which presented a situation that most people automatically consider inappropriate for their goals, actions, and plans. Such image could be selected by clicking it pressing on any mouse button. The possibility for using both buttons was directly articulated. Also, the participant was informed that both buttons were available to move to the next page in the instructions.

Figure 2. War

Figure 3. Peace

Figure 4. Recreation

Figure 5. Hard work

There were 18 pairs of images in opposite categories. The content of the presented categories was maximally simple (for example, "war" versus "peace" or "recreation" versus "hard work"). As a result, selecting an image in each pair was not difficult for participants. The categories were chosen by the authors, who found all images on the Internet. For each pair the authors chose one image that, in their opinion, corresponded to the participants' target (a target image). The nine target images were positioned on the left side of the screen; the nine other target images were positioned to the right. All images had the same size. The

order of the presentation of the pairs was random for each participant. There was no interval between the consecutive presented pairs.

If participants would prefer to select images describing situations which most people considered inappropriate for their goals and plans (i. e., if they would prefer to click the target images), this means that participants, to some extent, resist the rule of minimal construction costs at one level of the action.

To click an image, it was necessary to press on a computer mouse button. Both left and right buttons were available. There was no unequivocal requirement for the use of the right button, although there were several hints at this. As a result, it can be assumed that the joint construction of selecting an image should lead to the use of the left button, because pressing on the left button is the conventional method of interaction with a computer program that can be involved in the construction of selecting an image with minimal costs. If participants would prefer to press on the left button this means that participants did not resist the rule of minimal construction costs at another level of the action.

Accordingly, the hypothesis of the experiment was that participants prefer to select the target images by pressing on the left button of a mouse.

The number of the target images selected by a participant and the number of]= his/her presses on the right button were considered the outcome of the experimental session.

Instruction. The instructions consisted of several pages. First, a participant saw the following text at the top of the display:

Constructing their actions and goals, people automatically and unconsciously follow the principle of minimum activity. That is, when a person is planning some action or selecting a target, he/she would choose something being simple rather than complex, something being old rather than new, unless there are clear preferences or requirements. Similarly, people tend automatically to choose the standard mode of an action rather than a novel or unusual one.

Figure 6. Beautiful girl

Figure 7. Terrible mask

The following text was underneath:

For example, most people would link their objectives and activities with the beautiful girl in the left image rather than with the terrible mask in the right image, if the choice is not given more definitely. This happens automatically and unconsciously.

At the bottom, there was the caption "Press on any button of the mouse (track pad) to continue."

This was the first page of the instructions. After pressing on a mouse button, the first page was replaced by the second page. On the second page, the texts at the top and at the bottom stayed the same; however, the images and the text beneath were changed as follows:

Figure 8. Text in a foreign language

Figure 9. Text in the native language

People usually prefer actions and objectives relating to something in the native language, such as the text shown in the right image. They avoid anything associated with an unfamiliar, foreign language, such as the text shown in the left image.

On the third page the images and the text underneath were as follows:

Figure 10. Use of the left button

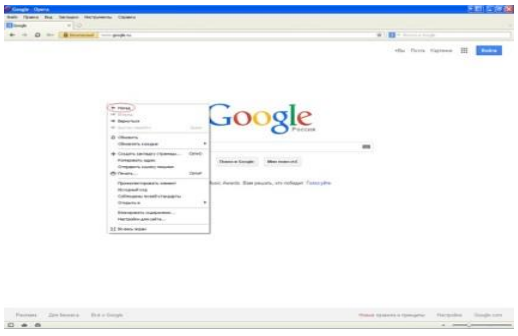

Figure 11. Use of the right button

While performing an action people also follow the principle of minimal actions. For example, to go back to the page in the browser, the person usually clicks the back arrow (marked with a red circle in the left picture) pressing on the left button of the mouse, although, it is possible to use the right button (marked in red in the right picture).

After the participant pressed on a button, the display was cleared and the following instruction was presented at the top of the display:

Instruction

Your aim is, to the greatest extent, to oppose the principle of minimal actions. You will see pairs of pictures. Choose an image in each pair with which most people would not associate their goals, actions, or plans. To select a picture, click it using any button of the mouse (track pad). Strive to resist the principle of minimal activity in all of its forms.

This text remained on the screen consistently during the presentation of image pairs underneath it.

It is important to note that the instructions were not intended to prime the use of the right button. Priming is usually considered the unconscious activation of a response[31] but the instructions attempted to activate the conscious awareness of the use of the right button.

After the completion of the experimental session participants were surveyed why they used or did not use the right button of the mouse. Two items were presented to the participants who used the right button:

I pressed on the right button because such an option was in the instructions.

I pressed on the right button to resist the principle of minimal actions.

Three items were presented to the participants who did not press on the right button:

I did not detect that the right button of the mouse was available.

I detected that the right button of the mouse was available but I decided that its use was unnecessary.

I don't know, I cannot explain why I did not use the right button of the mouse.

4.2 Results

There were 589 choices of the target images and 401 choices of the non-target images. We tested a hypothesis that the responses of participants were obtained from a binomial distribution with the equal probability of responses. For 990 choices this binomial distribution can be approximated by a normal distribution with mean equal to 495 and standard deviation equal to 15.73. A probability of the selection of 589 target images from this normal distribution is 0.000.

Only one participant used the right button, pressing on it four times. She selected the item "I pressed on the right button because such an option was in the instructions". Thirty (54.5 percent) participants decided that the use of the right button was unnecessary. Seventeen (30.1 percent) participants did not detect that the right button was available and seven (12.7 percent) participants could not explain why they did not press on the right button.

4.3 Discussion

A probability of the random selection of 589 target images is 0 this implicates that the participants understood the instructions and preferred to select the target images. Since the participants practically did not use the right button the hypothesis of the experiment was confirmed.

Because most of participants acknowledged that the right button was available the results of the experiment cannot be explained on the basis that using the left button of a computer mouse is a habit which is activated regardless of the intentions of participants. Taking into account that some participants simply could not explain why they neglected the right button it seems that the item that was selected after the experimental session only partially reflected a process which placed the choice of a button in the background of consciousness.

A skeptic may say that the results of the experimentation really do not confirm the suggestion that joint construction is the only factor underlying actions because the design of the experiment was unsatisfactory. The rule of minimal construction costs is a complicated and unusual concept; however, its description

in the instructions was possibly insufficient to explain this concept in detail. As a result, the participants did not become real experts in using the concept under circumstances being different from the situations explicitly described in the instructions. Some changes in the instructions could result in the use of the right button.

This argumentation is serious but its role seems limited. Of course, some changes in the instructions can influence the selection of a button. However, the action of selecting an image has more levels. Instead of hinting at a button of the mouse, it is possible to inform on the selection of a button in more details and to hint at a hand that is used to press on the mouse buttons. In this case, participants may become more attentive to selecting a button, nevertheless joint construction would determine their actions because participants would use the dominant hand.

The fact that it is not difficult to suggest an alternative explanation for the results means in the given experiment the activity of participants was not flexible enough. In future experiments the activity of participants should be more variable. For example, the present experiment can be replicated in conditions when participants should be familiarized with idea of joint construction in more details and their actions which can be used to violate joint synthesis should be less routine. However, in any experimental situation where the activity of participants is restricted alternative explanations are possible. Therefore, another approach to the examination of JCH can be based on studies of unrestricted behavior. The joint construction hypothesis posits that any form of activity is a goal-directed process based on minimal construction costs. If some unrestricted activities cannot be explained in terms of JCH this means that JCH is incorrect.

5. Conclusion

People describe and understand their behavioral and cognitive processes in terms of actions and the causation of actions could be the basis for a discipline explaining behavior and cognition. However, actions are extremely complex goal-directed processes with diverse means therefore understanding actions is extraordinarily difficult.

We posit that the goal and the means of an action are constructed jointly on the basis of the criterion of minimal construction costs. An assumption that joint construction entirely determines actions was examined in an experiment. The results of the experiment are consistent with the assumption. We suggest the joint construction approach is the necessary basis for understanding actions.

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