Motor Effects in Rating Lines' Length Using a Dichotomous Scale

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Abstract

The aim of this study is to demonstrate how the execution of particular task-specific motor movements can influence subjects' ratings of simple stimuli. Sixty-four participants in one control and two experimental groups rated lines of 36 different lengths. Lines appeared on a computer screen and subjects gave their ratings using a standard keyboard. In the experimental groups trials did not change automatically, but subjects had to press a specific button (called the "trial change button"), which was next to one of the response buttons. It was hypothesized that this manipulation would lead to assimilation of the ratings toward the category whose button was next to the trial change button. The results confirmed this hypothesis. Possible explanations of the results are discussed.

Keywords: context effects; scale ratings; grounded cognition; motor actions.

Introduction

According to traditional views in psychology and cognitive science, the role of sensory and motor processes in cognition is only peripheral. Our sensory organs receive information from the outside world and that information is transduced into amodal symbols which represent knowledge. High-level cognition (language, memory, decision making, problem solving, etc.) consists of the interaction of these symbols with each other, the product of which is either the activation of other amodal symbols, or their transduction into motor commands.

Researchers from the field of grounded cognition (Barsalou, 2008) assign a very different role to our sensory and motor systems. According to that view, the brain does not explicitly represent amodal symbols, but rather high-level cognition emerges from the interaction between the brain, the body, and the environment. This can also be stated by saying that high-level cognition is grounded in sensory and motor representations, not amodal, abstract symbols.

An ample amount of empirical results supports the views of grounded cognition. Evidence shows that haptic, visual, auditory sensations, proprioception, as well as execution of motor actions, all influence higher-level cognitive processes, like memory, language processing, visual and motor imagery, and so on (for a review, see Barsalou, 2008).

The aim of this study is to demonstrate how motor actions required for the execution of a particular cognitive task can affect high-level cognitive processes. More specifically, we are going to try to show this by demonstrating how motor actions necessary to perform a scale rating task can influence the ratings.

There already exists a field in psychology which deals with the so-called context effects in scale ratings. There is bountiful experimental literature demonstrating changes in subjects' ratings, influenced by factors like the range of the stimuli, their distribution, the sequence of their presentation, and so on.

Some of the studies demonstrate how context can systematically[1] change the ratings of stimuli evaluated only by one dimension. Examples include judgments of square sizes (Parducci & Perrett, 1971; Sarris & Parducci, 1978), weights (Parducci & Marshall, 1962; Sherif, Taub, & Hovland, 1958), and the length of lines (Kokinov, Hristova, & Petkov, 2004; Petrov & Anderson, 2005).

Other studies demonstrate contextual effects in the ratings of more complex stimuli (stimuli that must be evaluated based on more than one dimension). For example, Cooke & Mellers (1998) asked participants to rate flats' attractiveness based on their rent, number of rooms, and distance from campus. Mellers (1982) demonstrates such effects in equity judgments, and Wedell, Parducci, & Geiselman (1987) show contextual effects in ratings of the attractiveness of female faces.

There are a number of influential theories which try to explain such experimental results. One of the first theories in the field is the **adaptation-level theory** (Helson, 1964). According to that theory, the stimuli a person has rated leave a general impression with which all other stimuli are compared while being assessed. Another powerful theory in this field is the **range-frequency theory (**Parducci, 1965, 1968, 1974). It claims that a stimulus' rating is a compromise between the range and frequency principles. The former refers simply to the lower and higher end of the stimulus material (e.g., the smallest and the biggest square, if the task is to judge the size of different squares). The latter principle is concerned with the distribution of the stimuli (e.g., uniform, positively or negatively skewed, etc). Discussing in detail these and other theories in the field of contextual effects in scale ratings is beyond the scope of this paper.

To our knowledge, there are no studies showing changes in people's ratings of stimuli caused by "peripheral" factors like the specific motor actions executed during the process of rating itself. Furthermore, none of the theories presented

[1] For a change to be considered systematic, it has to be in one particular direction. When the change is in the direction of the context (e.g., when there are more big squares than small squares in the stimulus material and an average square receives a higher rating than normal), the effect is called *assimilation*, whereas when the change is in the opposite direction of the context, the effect is called *contrast* or *compensation*.

above predict any such effects. As was mentioned earlier, the aim of the current study is to demonstrate how task-specific motor actions can influence subjects' performance in the task. Next, we will review some of the literature concerned with how executing particular motor actions affects some cognitive processes which don't seem to be directly related to the motor actions.

Motor Effects in High-Level Cognitive Processes

In this section, we will briefly present empirical results showing how different motor actions can influence high-level cognitive processes. The most commonly used experimental paradigms are described below.

Cacioppo, Priester, & Berntson (1993) use the isometric arm flexion and extension paradigm to trigger the so-called approach and avoidance systems. The authors argue that when these systems are activated, stimuli that people interact with are perceived as more positive or more negative, respectively. In a series of experiments they ask subjects to either place their palms at the bottom of a table and to lift slightly (flexion condition) or to place their palms at the top of the table and to push slightly (extension condition), while at the same time observing Chinese ideographs which they later rate as pleasant or unpleasant. The results show that ideographs observed during arm flexion are later rated as more pleasant, whereas those observed during extension are rated as less pleasant.

Another commonly used method is inducing a smile or a frown by asking subjects to hold a pen or a pencil with their teeth or with their lips, respectively. The muscles activated during these actions are also active during one of the above facial expressions. Using this manipulation, Strack, Martin, & Stepper (1988) showed that holding a pen between the teeth or between the lips leads to evaluating cartoons as funnier or less funny, respectively.

Head nodding or shaking are meaningful gestures in most cultures. They convey agreement/disagreement with or approval/disapproval of someone else's behavior, a witnessed event, etc. Wells & Petty (1980) used the association between the type of head movement and the created mental set toward the currently active concepts to show that making vertical head movements while listening to a message leads to higher agreement with the message, whereas making horizontal movements leads to lower agreement.

For a review of other experiments showing motor influence on high-level cognitive processes, see Briñol & Petty (2008).

Possible Explanations of These Findings

The explanation that most papers provide for the obtained results is related to the existing associations between a motor action and a cognitive response (e.g., nodding associated with agreement). These associations are created during a person's life and influenced by their culture. But how are they created?

Zwaan & Madden (2005) provide one possible mechanism by which such associations can be established. According to their **interconnected experiential traces** theory, all mental representations are experiential, that is, created during some form of interaction with the outside world. They define two types of representations: **referent** and **linguistic**. The former are multimodal memory traces laid down during interaction with the environment. The latter representations are laid down during receiving or producing linguistic information (e.g., talking, listening, writing, etc.). A very important feature of these representations is that they can be interconnected (associated).

The authors propose **co-occurrence** as a possible mechanism for establishing these associations. When two events occur simultaneously or in succession, the neural assemblies which represent those events establish stronger connections with each other (Hebb, 1949). For example, the visual image of a falling glass of water is likely to be associated with the sound of breaking glass. This happens because in a person's lifetime, the experience of a glass falling on the ground from a certain height has almost always been followed by a specific sound (that of breaking glass). Thus, that person develops anticipation for that sound after seeing a falling glass.

Experiment

Likert scales are often used in pilot studies or even as dependent measures in experiments. Researchers exploring contextual effects in ratings have showed that these measures can sometimes be affected by factors other than those being investigated by the particular study (see studies reported in the introduction). However, they have emphasized on "cognitive" factors and have not studied any possible influence of sensory or motor processes on subjects' ratings. The current experiment's goal is to make the first step in filling this gap by demonstrating changes in subjects' ratings influenced by the specific hand movements they make while rating lines of different lengths.

One common feature of the experiments demonstrating motor effects in high-level cognitive processes reviewed in the previous section is that they all exploit associations between different types of representations that have already been formed throughout participants' lives. The current experiment will try a different approach by attempting to *create* new short-term associations between particular motor movements and conceptual categories.

Having in mind the interconnected experiential traces theory of Zwaan & Madden (2005), it can be hypothesized that if the activation of a particular category is repeatedly coupled with the execution of a motor action, a temporary association between the respective category and motor action might be created. After that, the execution of the motor action alone may be sufficient to activate the category with which it was associated.

Hypotheses

In the current experiment, participants' task was to rate lines' lengths using a dichotomous scale (a line could be rated as "short" or "long"). If the motor actions (hand movements) required for giving one of the two responses are different in nature this can lead to the creation of a new associative connection between them (i.e., between one of the two categories and the respective hand movement). If, then, one of the motor actions is activated, it should also activate the associated category.

When one of the two categories is more active than the other, this can *increase* the probability of the line being currently rated to receive that particular rating (e.g., a middle-sized line may be rated as "long" if that category's base-level activation is higher that usual). This hypothesis was tested using the procedure described below.

Method

Participants 64 New Bulgarian University (26 males, 38 females) undergraduate students volunteered for this study.

Stimuli The stimulus material consisted of 36 lines of different lengths appearing in the middle of a computer screen. The shortest line was 38 pixels and the longest line was 668 pixels, with an increment of 18 pixels. Lines were 2 pixels thick.

Apparatus Lines were presented on a 17'' TFT monitor with a resolution of 1024 x 768 pixels. The responses were obtained using a standard computer keyboard. The experimental script was written with the E-Prime 1.1 software.

Design and procedure The experiment was conducted in small rooms with each participant being tested individually. Subjects sat in front of a computer and the instructions were presented to them in written form across the screen, as well as explained to them by the experimenter. In short, the instructions said that subjects would take part in a study concerned with people's judgment of length and that their task would be to rate different lines presented on the screen as "short" or "long" using the two specified buttons on the keyboard.

The experiment employed a between-subject design with one control group and two experimental groups (see Table 1). In the control group the procedure was the following: after they heard the instruction subjects went through a training session to be familiarized with the experiment. The training session was the same as the experimental session, but only 10 (out of 36) lines were presented in random order. In the experimental session all 36 lines were presented 2 times each, resulting in a total of 72 trials. Figure 1 shows what a single trial looked like.

The procedure in the experimental groups was identical to that of the control group, except for the transition between trials. In the experimental groups, subjects had to press an additional button at the end of each trial (called the "trial change button") in order to see the next trial (Figure 2). The trial change button was positioned either next to the "short" button or next to the "long" button (see Table 1).

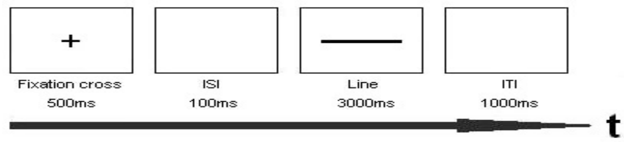

Figure 1: Every trial in the control group started with a fixation cross for 500 ms, followed by a 100 ms inter-stimulus interval, followed by a 3000 ms exposure of the line to be rated, and a 1000 ms inter-trial interval.

Subjects were asked to use only their right index finger to give their responses. Between every two trials they had to put their finger in a neutral position between the response buttons (the black rectangle in Figure 2)[2]. The sequence of actions in every trial (after the line's appearance on the screen) was: press one of the response buttons – press the trial change button – return to neutral position.

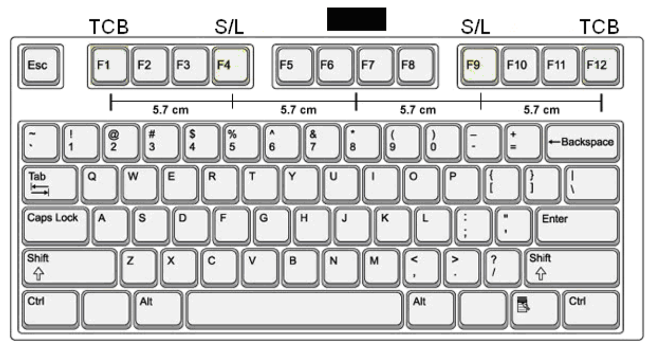

Figure 2: The F4 and F9 buttons were used as response buttons (for responding "short" or "long"), and the F1 and F12 buttons were used as trial change buttons. Both response buttons and trial change buttons were counter-balanced across conditions.

The dependent measure in this study was the response to each line ("long" vs. "short").

Table 1: The position of the trial change button with respect to the response buttons in the three groups.

	Ex. Group 1	**Ex. Group 2**	**Control Group**
TCB next to	"Long" button	"Short" button	No TCB

After the end of the experiment, subjects were debriefed, thanked, and dismissed.

[2] All other keyboard button functions were disabled, so pressing other buttons accidentally did not affect the experimental procedure. Thus, subjects were instructed to rest their wrists on the keyboard without worrying about accidentally pressing buttons other than those which were part of the procedure.

According to the main assumption in this study, the different types of movements should be associated with one of the two categories. That is, the categories "long" and "short" should be associated with a hand movement to the left or a hand movement to the right (depending on the experimental condition). Since in the two experimental groups the position of the trial change button also requires a hand movement either to the left or to the right immediately before the presentation of the next line to be rated), that movement should activate the respective category more than its rival category and the probability that each line is rated with that category should increase.

Results and Discussion

The expected results following this manipulation were that there is going to be an assimilation of the responses toward the position of the trial change button. That is, if the trial change button is next to the "long" response button, the probability that an arbitrary line is rated as "long" should be higher than in the control group, and if the trial change button is next to the "short" response button, the probability should be lower. The actual results confirmed these expectations (Figure 3).

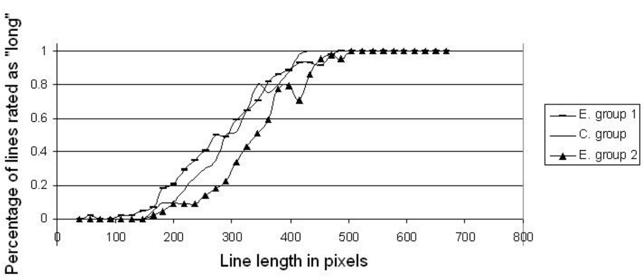

Figure 3: The probability for every line to be rated as "long" in the three conditions. As was expected, in experimental group 1 more lines were rated as "long" and in experimental group 2 more lines were rated as "short", in comparison with the control group.

All individual responses (the number of individual responses was *number of subjects * number of trials per subject*) were divided in three groups (the two experimental groups and the control group). "Long" responses were coded as "1", and "short" responses were coded as "0". A chi-square analysis was performed in order to test if the results in the three groups differed significantly, χ^2 (2) = 26.54, $p < 0.01$. The standard residuals[3] are given in Table 2. As can be seen, the two experimental groups were the main contributors for the significance of the results.

Since this analysis had too many individual measures, for a higher certainty in the significance of the results a repeated-measures ANOVA was also performed after aggregating the data for individual lines (that is, one individual measure stood for the percentage of a particular line rated as "long" in one of the three conditions), F (1, 35) = 68.11, $p < 0.001$. Three individual t-tests were performed to compare the three groups. The analyses revealed significant results between experimental group 2 and the control group, t (35) = 4.38, $p < 0.001$, ES = 0.73, also between experimental groups 1 and 2, t (35) = 4.98, $p < 0.001$, ES = 0.83, and marginally[4] significant results between experimental group 1 and the control group, t (35) = -2.3, p = 0.027, ES = 0.4.

Table 2: The standard residuals for the chi-square analysis.

	"Short"	**"Long"**
Control Group	-,9	,8
Ex. Group 1	-2,2	1,9
Ex. Group 2	3,1	-2,7

These results show that the presence of a trial change button always affects subjects' ratings. However, it is also evident that there is an asymmetry in the difference between the two experimental groups and the control group. That is, when the trial change button is next to the "short" response button the effect is stronger than when it is next to the "long" response button. This and other questions are discussed in the next section.

General Discussion

The results of this study showed that "non-cognitive" factors can also affect "cognitive" processes like judgment and categorization under certain circumstances. We think these results contribute to both the field of embodiment and grounded cognition, as well as to the field of context effects in scale ratings. The two main findings are: (1) task-specific motor actions can potentially affect subjects' ratings in a scale rating task, and (2) temporary associations between referent and/or linguistic representations can be established even for a short period of time.

Of course, there still remain a lot of open questions. In relation to the first finding, one thing that needs to be explored empirically is whether the same results can be obtained with a larger scale (e.g., a 7-point Likert scale). One might argue that the task in the current study was not scaling at all, but rather simple categorization.

[3] Standard residuals are used to determine which cells contribute most for the rejection of the null hypothesis in a chi-square analysis. Absolute values equal to or greater than 2 are considered statistically significant.

[4] Due to the increasing probability of making a type I error when performing more than 1 t-test on overlapping statistical data, the acceptable level of significance was not 0.05, but was set to $\alpha = 1 - \sqrt[3]{(1 - 0.05)} = 0.017$. For that reason p = 0.027 is considered a marginally significant result.

Another open question regarding the first finding is concerned with the observed asymmetry between the two experimental groups. All performed statistical analyses showed that the assimilation is stronger when the trial change button was next to the "short" response button than when it was next to the "long" response button. A possible explanation for this result can be found in the linguistic notion of **markedness** (Andrews, 1990). This term was coined by the Russian linguist Nikolai Trubetzkoy. Even though he used it to explain some phonological phenomena, other authors later extended the notion to other linguistic fields, including semantics. An unmarked form of a concept is a basic and natural form, whereas a marked form is one that is derived from the unmarked form. For example, lioness is the marked form of lion, since lion can refer to both male and female lions, whereas lioness only refers to female lions. Since, as was mentioned earlier, the task that subjects received in this experiment can be considered categorization, some markedness effects can also be observed. When talking about the size of a line, it is more natural to think about its "length", rather than its "shortness". This suggests that "long" is the unmarked category, and "short" is the marked category[5]. That might be the reason why the experimental manipulation was weaker for the experimental group in which the trial change button was next to the "long" response button. Subjects are simply more confident in responding "long" than in responding "short". However, this clearly is a *post-hoc* explanation and needs further confirmation.

It has also been brought to our attention that the results could be explained by assuming that subjects press the button closer to the TCB in order to save time and effort and not because of the activated referent or linguistic representations. This is a valid point and needs to be addressed in future studies.

Regarding the second finding in this study, the open questions are concerned with the exact mechanisms underlying these associations. Zwaan & Madden (2005) propose a sound theory, but it is not specified in enough detail.

Returning to the current study, one interesting question is related to the exact representations that are associated. Throughout this paper, it was assumed that the semantic category ("long" or "short") is associated with the particular type of movement (hand movement to the left or to the right). A second possibility is that it is the visual image of a button that is associated with the respective category. In that case, every time subjects have to press the trial change button, their attention is directed toward the respective response button too, and that activates its category. The results of the current experiment are unable to disambiguate between these possibilities.

Future Studies

It is clear that there are a lot of open questions that need to be investigated empirically. In this section, we will propose two experiments that might clarify some of them.

The first one is a natural extension to the current study. Namely, can the same results be obtained if there are more than two responses, that is, if a larger scale is used? The procedure in that study is going to be the same, but there are going to be more than two response buttons (e.g., 7 buttons for a 7-point scale) and again the trial change button is going to be placed at one side of the scale. If our hypothesis is correct, the same assimilation effect should be observed.

The second proposed experiment is aimed at answering the question of whether or not the obtained results are simply due to the fact that subjects' attention is being directed towards a particular response button every time they press the trial change button (see the discussion in the previous section) or if the results are due to a time/effort saving incentive. The proposed procedure is the following.

There are going to be three experimental sessions. In the first session, subjects will have the same rating task as in the current study (i.e., rating lines' lengths). However, instead of "long" and "short", the available response categories are going to be "big" and "small". If the assumptions made in this paper are correct, during this session these categories should be temporarily associated with the hand movements required for giving these responses.

In the second session, subjects will have a task whose goal will be to make them press one of the two response buttons more frequently than the other (e.g., a circle will appear on the left or on the right side of the screen and the subjects' task will be to press the respective button on the keyboard; the circle will appear more frequently in the right or in the left, depending on subjects' experimental condition). Again, if the assumptions made in this paper are correct, this should make the movement that has been executed more frequently more active than the other movement, and that would make the associated category more active as well.

In the third experimental sessions, subjects will have a task identical to that of the first session, but the stimuli will be different (e.g., rating squares, instead of lines), but again using the same categories for responses ("big" and "small"). If one of the two categories is more active than the other (because of the manipulation in the second experimental session) this should lead to a higher probability of responding with that category. Since in no part of this procedure is there any trial change button, the "attention" and time/effort saving explanations of the results can safely be ruled out.

Both proposed experiments are going to be performed in the near future.

[5] Results from the control group support this hypothesis. About 60% of the lines were rated as long, and only 40% as short, $\chi^2(1) = 45.93$, $p < 0.001$ (this difference would not be expected if subjects have no bias toward either category). It seems that subjects find it more natural to call a middle length line "long", rather than "short".

Conclusions

This study showed effects of motor actions on the process of rating lines as "long" or "short". The results are considered to contribute to both the field of grounded cognition and the field of context effects in scale ratings (or even to fields like psychophysics, if the effects of the methodology of measuring subjects' perceptions for different stimuli are to be taken seriously).

There are still many open questions which must be further explored. Despite all uncertainties however, these results show that it is quite likely that sensory and motor processes can be significant factors in the process of scaling (a finding that is not predicted by the main theories explaining contextual effects in scaling).

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