PSYCHOLOGICAL SCIENCE

Research Article

Embodied Preference Judgments

Can Likeability Be Driven by the Motor System?

Sian L. Beilock[1] and Lauren E. Holt[2]

[1]*The University of Chicago and* [2]*Miami University of Ohio*

ABSTRACT—*Can covert sensorimotor simulation of stimulus-relevant actions influence affective judgments, even when there is no intention to act? Skilled and novice typists picked which of two letter dyads they preferred. In each pair, one dyad, if typed using standard typing methods, would involve the same fingers (e.g.,* FV*); the other would be typed with different fingers (e.g.,* FJ*). Thus, if typed, dyads of the former kind should create more motor interference than dyads of the latter kind. Although individuals could not explain how the dyads differed, skilled typists preferred those typed with different fingers. Novices showed no preference. Moreover, a motor task performed while making dyad preference judgments attenuated skilled typists' preference—but only when the motor task involved the specific fingers that would be used to type the dyads. These findings suggest that in skilled typists, perceiving letters prompts covert sensorimotor simulation of typing them, which in turn influences affective judgments about this information.*

Traditional views of cognitive psychology characterize the mind as an abstract information processor largely divorced from the body and the environment. However, more recent theories of embodied cognition suggest that the ability to represent objects and events is subserved by the sensorimotor systems that govern acting on these objects and in these events (e.g., Barsalou, 1999; Glenberg, 1997; Wilson, 2002; Zwaan, 1999). This embodied viewpoint has roots in ecological psychology's refutation of a distinction between perception and action (Gibson, 1979) and finds support across multiple levels of psychological inquiry.

For example, the discovery of overlap between neural regions involved in the observation of action and neural regions involved in the production of action (e.g., premotor and motor cortex; Decety & Grezes, 1999; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996) has been taken to suggest that the human motor system not only plans actions to be executed, but allows them to be represented as well (Garbarini & Adenzato, 2004). Moreover, evidence of overlap between the neural areas involved in action observation and production has not been limited to studies of observed action per se, but has also been obtained in studies in which subjects merely hear or recall stimuli with strong action associations. Reading action words associated with the leg and arm (e.g., *kick*, *pick*) activates brain areas implicated in the movements of these body parts (Hauk, Johnsrude, & Pulvermuller, 2004; Tettamanti et al., 2005). Similarly, when individuals skilled in writing kanji characters retrieve these characters from memory, they show motor-system activation in areas associated with actually writing these characters (e.g., contralateral premotor cortex, pre-supplementary motor area, and bilateral intraparietal sulcus)—even when they have no intention to write them (Kato et al., 1999).

The notion that the representation of objects and events is grounded in action is also supported on a behavioral level. Sensibility judgments in response to sentences such as "Can you squeeze a tomato?" are facilitated when participants are primed with an associated hand shape (clenched hand) relative to an inconsistent hand shape (pointed finger; Klatzky, Pellegrino, McCloskey, & Doherty, 1989). And reading about someone performing a motion-directed act (e.g., "Eric turned down the volume") activates motor plans associated with actually producing this action (Zwaan & Taylor, 2006). Such findings suggest that comprehension is interconnected with the systems involved in understanding and planning actions (Glenberg & Kaschak, 2003; Holt & Beilock, 2006). Moreover, Knoblich and his colleagues (Knoblich & Flach, 2001; Knoblich, Seigerschmidt, Flach, & Prinz, 2002) have used the fact that individuals are better able to predict the outcome of an action (e.g., dart throwing) when watching a video of themselves than when watching a video of another person to argue that action prediction is driven by sensorimotor simulation (Wilson & Knoblich, 2004). If the motor system underlies action prediction, then predictions should be best when the systems used to predict and produce reside in the same individual—exactly what is found.

Address correspondence to Sian L. Beilock, Department of Psychology, 5848 South University Ave., The University of Chicago, Chicago, IL 60637, e-mail: beilock@uchicago.edu.

Together, these behavioral and neurophysiological findings suggest that people represent their surroundings, at least in part, via covert sensorimotor simulation of how they might execute an observed behavior or act on the objects they encounter. In the current study, we broadened this conception of bodily influence to include affective judgments about stimuli in the environment. In two experiments, we capitalized on skill in the domain of typing and the logic of selective motor interference to demonstrate that covert sensorimotor simulation of stimulus-relevant actions influences affective judgments about the stimuli—even though this motor-affect link is not mandated by the task in question.

Skilled and novice typists were simultaneously presented with two separate letter dyads and asked to indicate which dyad they preferred. The dyads presented fell into two categories: dyads that would be typed with the same finger using standard typing methods (e.g., *FV*) and dyads that would be typed with different fingers (e.g., *FJ*). Each dyad pair included one dyad from each category (this paradigm was first used by Van den Bergh, Vrana, & Eelen, 1990). Because typing is thought to involve the overlap of successive key strokes (Rumelhart & Norman, 1982), typing two letters with the same finger should result in more motor interference than typing two letters with different fingers, as the former action requires that the same digit essentially be in two places at once (or in very close succession).

Results demonstrated that skilled typists preferred dyads typed with different fingers (i.e., dyads that were not functionally incompatible) significantly more than chance. Novices showed no preference. Moreover, participants were unaware of the link between our study and typing and, when asked, could not explicate how the dyads differed (i.e., that they were typed with the same finger vs. with different fingers). Although this preference effect has been reported previously (see Van den Bergh et al., 1990), no mechanistic explanation exists. Why might skilled typists show the letter-dyad preference that novices do not? If typing experience results in the association between specific letters and the motor programs used to type them, and if perceiving letters automatically activates these motor plans (Rieger, 2004; see also Prinz's, 1997, common-coding theory), then when a typist is presented with letters, such covert simulation of typing should provide the typist with information about the relative interference involved in typing these letters. And if individuals prefer to act in ways that reduce interference, they should prefer letter dyads that, if acted on, would result in the least amount of motor interference.

The current experiments explicitly tested these claims. On some trials in Experiment 1, while participants made their preference judgments, they held in memory a finger-press pattern that involved the same fingers that would be used to type the presented dyads. If holding such a pattern utilizes motor-system resources that would otherwise be used to inform typists' preference judgments, such preferences should disappear in this condition—and they did. Experiment 2 showed that this motor interference was specific to the digits actually involved in typing the dyads. When expert typists held in memory a motor pattern involving fingers not used to type the dyads, the preference remained. Thus, not only does covert sensorimotor simulation of acting on the information one perceives influence preference judgments, but this simulation is specific to the effectors involved in the simulated action.

EXPERIMENT 1

In this experiment, skilled and novice typists were asked to indicate which of two letter dyads they liked better, under both single- and dual-task conditions. All letters that were presented would be typed with the index or middle finger using traditional touch-typing methods. One dyad in each pair consisted of letters that would be typed with the same finger, and the other consisted of letters that would be typed with different fingers. In the single-task condition, individuals made preference judgments in isolation. In the dual-task condition, prior to making the preference judgments, participants were trained to associate two random symbols with button-press patterns involving the fingers that would be used to type the dyads (a paradigm adapted from Klatzky et al., 1989). Each trial began with the presentation of one of these symbols. Participants then made their dyad preference judgment and finally performed the motor pattern associated with the symbol. If experience with typing affords the mapping of letters and their associated motor plans, and if such associations are automatically activated upon stimulus presentation in a way that provides information about functional interference, then skilled typists should prefer letter dyads typed with different fingers over those typed with the same finger—at least to the extent that people prefer to act in ways that limit interference. Novices should show no preference. Furthermore, if the preference is due to covert motoric simulation of typing the presented dyads, then consuming the motor system with a motor program to be executed (the trained button-press pattern) should wipe out this preference.

Method

Subjects

Participants were recruited for a study examining "cognitive task performance"; the description of the study made no mention of typing. Following completion of the study, participants were categorized as skilled or novice typists. They were considered skilled typists if they (a) had taken a formal typing course, (b) typed a minimum of 3 hr/week, and (c) reported that they kept their fingers on the "home keys" (i.e., ASDFJKL) when typing and only occasionally looked at the keyboard (criteria adapted from Van den Bergh et al., 1990). The 29 skilled typists typed, on average, 51.5 words/min without any errors (*SE* = 2.5). One skilled participant was removed for failing to score above 75% correct on a typing manipulation check at the end of the experiment. Participants were classified as novices ($n = 16$) if they failed to meet all three of the criteria ($M = 27.8$ words/min, $SE = 5.2$). The novices typed significantly more slowly than the skilled typists, $F(1, 43) = 17.16, p < .01$.

Materials

Thirty-two letter dyads were formed from letters typed with the left middle, left index, right index, and right middle fingers. Half of the dyads consisted of letters typed with the same finger on the same hand (e.g., *FV*), and the other half consisted of letters typed with different fingers on different hands (e.g., *CJ*). Dyads were not meaningful, were minimally pronounceable, and did not rhyme.

Dyads were randomly paired such that each pair consisted of one same-finger dyad and one different-fingers dyad, with no overlap in letters. Two different pairings of dyads were used to create eight versions of the experiment; within each pairing, the left/right position of the dyads within a pair was counterbalanced across participants, as was whether the pair was presented in the single- or dual-task block of the experiment. Letters were presented in 28-point Courier New font, at the center of the screen; the separation between paired dyads was approximately 7.5 in.

Procedure

After giving informed consent, participants were instructed to place their fingers on eight white squares on a keyboard. The experimenter placed a cover over participants' hands to obstruct them from view. A microphone was placed on top of the cover. Participants were informed that on each trial, they would see two letter dyads on the screen and they should verbally indicate which of the two dyads they preferred, using their first impressions of the letters; they were instructed to avoid choosing dyads on the basis of their associations with any initials or abbreviations. Participants were instructed to say "1" if they preferred the dyad on the left side of the screen and to say "2" if they preferred the dyad on the right side of the screen. Participants' voices triggered the microphone, causing the dyads to disappear. After a 750-ms blank screen, the next pair of dyads appeared. The experimenter manually recorded participants' preferences. Individuals completed both a single-task and a dual-task block, with block order counterbalanced across participants.

Single-Task block. In this block, participants made eight preference judgments between dyad pairs. The pairs were presented in a different random order for each participant.

Dual-Task block. Prior to the dual-task block, participants were trained to associate two symbols, ".|." and "<->," with two button-press patterns. Each pattern required using four fingers to make four consecutive finger presses on the keyboard. The fingers used for these patterns were the left middle, left index, right index, and right middle fingers—the same fingers that would be involved in typing the dyads given touch-typing conventions. During training, participants first saw one of the symbols for 1,000 ms and were then presented with a screen consisting of eight white boxes (Fig. 1). Each box represented one of the keys marked with white squares on the keyboard (i.e., the keys upon which participants' fingers rested). In 1,000-ms time intervals, the four keys turned black one at a time, indicating which finger was to be pressed next (e.g., ".|." required sequentially pressing the left middle, right middle, right index, and left index fingers, in that order). Participants saw this display two times. Next, they practiced the pattern eight times as quickly and accurately as possible and received feedback on their performance. They had the option of repeating the pattern they had just practiced four more times.

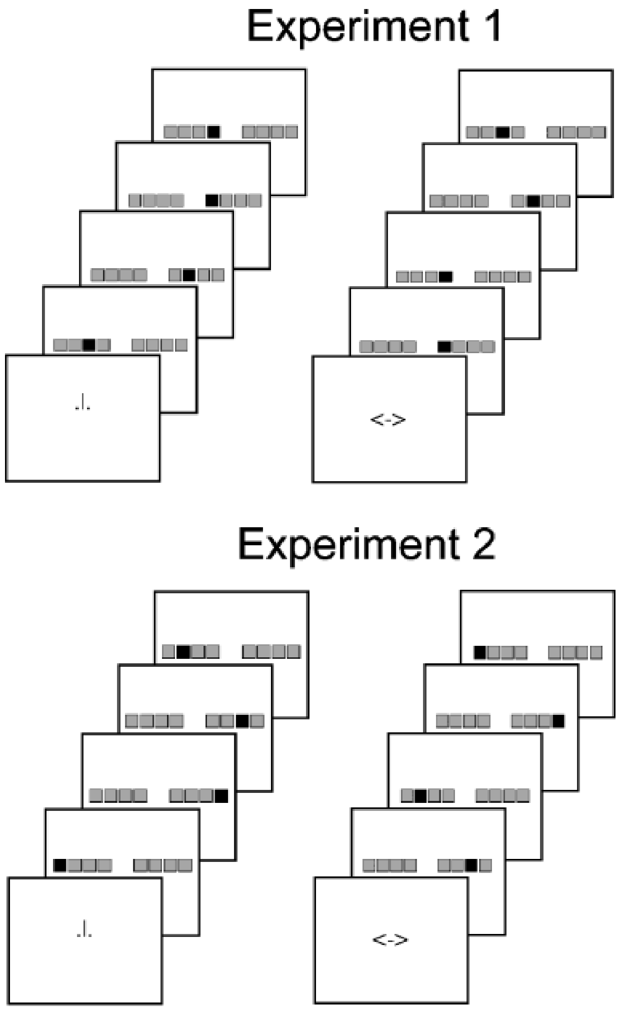

Fig. 1. Graphic displays presented during dual-task training in Experiments 1 and 2. Participants first saw one of the symbols (".|." or "<->") for 1,000 ms. Participants were then presented with a screen consisting of eight white boxes (shown here in gray). Each box represented one of the keys marked with white squares on the keyboard (i.e., the keys on which participants' fingers rested). In 1,000-ms time intervals, the four keys turned black one at a time, indicating which finger was to be pressed next. For example, in Experiment 1, ".|." required the sequential pressing of the left middle, right middle, right index, and left index fingers.

The second symbol and pattern were learned in the same manner. The order in which the two patterns were learned was counterbalanced across participants.

After learning both patterns, participants completed a testing block in which each symbol was randomly presented 20 times, followed by a prompt to type the associated finger-press pattern and then feedback on performance. If participants' cumulative accuracy fell below 80% at any point after the first 8 of the 40 trials, the testing block restarted.

Following training, participants completed the dual-task block. Each trial began with the presentation of one of the symbols from training (1,000 ms) and then a 1,000-ms blank screen. Next came the dyad judgment task. Finally, a cue appeared, and participants executed the button-press pattern corresponding to the symbol they saw at the start of the trial. They then received feedback on the accuracy of the button-press pattern. As in the single-task block, participants completed eight trials. Each symbol was presented four times. Dyad pairs were presented in a different random order across participants.

After the experimental blocks, participants were presented with two columns of letter dyads. One column consisted of all the same-finger dyads seen in the experiment, and the other column consisted of the different-fingers dyads. Participants were asked to determine the rule used to create the two columns of dyads (i.e., to indicate what made the columns different). Participants then completed a 2-min computerized typing test used as a manipulation check to assess typing speed and accuracy and completed a demographics sheet assessing typing proficiency. Everyone was then thanked and debriefed.

Results

Scoring

To create a dependent variable indicating preferences for same-finger or different-fingers dyads, we assigned a score of 1 to each trial on which the same-finger dyad was preferred, and a score of 0 to each trial on which the different-fingers dyad was preferred. For each participant, these values were summed and divided by the total number of trials in each block. Thus, a score of .5 indicates no preference, a score less than .5 indicates a preference for different-fingers dyads, and a score above .5 indicates a preference for same-finger dyads. Four judgments (three from single-task trials and one from dual-task trials) were lost because of microphone errors (less than 0.5% of all data). Moreover, we used dual-task preference scores only from those trials in which participants produced the correct finger pattern. However, participants were extremely accurate in performing the dual-task finger patterns ($M = 94\%, SE = 1.5\%$). Including all trials would not have changed the pattern of results.

Preference Judgments

A 2 (typing expertise: novice, skilled) × 2 (block: single-task, dual-task) analysis of variance on preference scores revealed a significant Expertise × Block interaction, $F(1, 43) = 4.48, p < .05, p_{\text{rep}} = .89, \eta^2 = .09$ (Fig. 2). Novices showed no preference for either kind of dyad under either single-task or dual-task conditions. Preference did not differ from chance in either the single-task condition, $t(15) < 1$, or the dual-task condition, $t(15) < 1$. Skilled typists preferred dyads typed with different fingers significantly more than chance in the single-task condition, $t(28) = 2.6, p < .02, p_{\text{rep}} = .96, d = .71$, but not in the dual-task condition, $t(28) < 1$. Forcing skilled typists to hold a motor plan in memory attenuated their preference for dyads that (when typed) do not create motor interference.

Fig. 2. Novice and skilled typists' letter-dyad preferences in the single-task and dual-task blocks of Experiments 1 and 2. A score of .5 indicates no preference (i.e., chance, indicated by the dark line), a score less than .5 indicates a preference for different-fingers dyads, and a score above .5 indicates a preference for same-finger dyads. Error bars represent 95% confidence intervals.

Typing Rule

Only 1 participant was able to partially identify the rule distinguishing the dyads, reporting that some dyads were "made just with the left hand." It is unclear whether this knowledge (assessed after the experiment) affected this person's preference judgments. Nonetheless, excluding this participant from the analysis did not change the results.

Discussion

Experiment 1 demonstrates that skilled typists prefer letter dyads that, if typed, would not create motoric interference. Novice typists do not show this preference. Although this effect has been demonstrated previously (see Van den Bergh et al., 1990), no mechanism has been put forward to explain it. To establish that such an effect is due to the covert sensorimotor simulation of typing the presented letter dyads—even without the intention to type—we employed a dual-task condition that forced individuals to hold a motor pattern in memory while making their preference judgments. When the motor system was consumed with this task, skilled typists' preference disappeared. The fact that the motoric task attenuated skilled typists' preference suggests that covert sensorimotor simulation of stimulus-relevant actions influences affective judgments about these stimuli. When such simulation is not possible, the effect disappears.

One might argue that rather than co-opting the motor system, the motoric task instead utilized attentional resources in a manner that prevented skilled typists from making consistent preference judgments. This explanation does not seem likely given that individuals could not explicate how the dyads differed, which suggests that they were not using explicit processes to choose one dyad over another (Beilock & Carr, 2001). Nonetheless, to rule out this possibility, we conducted a second experiment, in which the motoric task involved fingers not used to type the dyads. If the motoric task in Experiment 1 simply served as an attention-demanding distraction, then Experiment 2 would be expected to produce the same results. However, if the motoric task in Experiment 1 prevented sensorimotor simulation of typing the dyads, a motoric task involving fingers not used to type the dyads would not be expected to affect preferences. Such a result would suggest not only that covert sensorimotor simulation of typing perceived letters affects skilled typists' preference judgments, but also that this simulation is digit-specific.

EXPERIMENT 2

Skilled and novice typists performed the same dyad preference task as in Experiment 1, in both single-task and dual-task conditions. However, in Experiment 2, the button-press patterns individuals held in memory in the dual-task condition involved fingers that would not be involved in typing the presented dyads using traditional touch-typing methods.

Method

Participants

Individuals were categorized as expert or novice typists using the same criteria as in Experiment 1. Two skilled typists were removed from the analyses because they failed to score above 75% correct on the typing manipulation check at the end of the experiment. The final sample included 20 skilled typists who typed, on average, 61.5 words/min ($SE = 2.8$). The novices ($n = 22$) typed significantly more slowly ($M = 39.0$ words/min, $SE = 4.9$), $F(1, 40) = 14.98$, $p < .01$.

Materials and Procedure

All materials and procedures were identical to those used in Experiment 1 with one exception: The button-press patterns involved the left pinky, left ring finger, right ring finger, and right pinky. The left-to-right order of the button-press patterns was the same as in Experiment 1, with spatial location shifted to the outside fingers (Fig. 1). Thus, the fingers used to execute the button-press patterns in Experiment 2 were different from the fingers that would be used to type the letter dyads using touch-typing conventions.

Results

Scoring

Scoring procedures were identical to those used in Experiment 1. Three judgments (two in the single-task condition, 1 in the dual-task condition) were lost because of microphone errors (less than 0.5% of all data). As in Experiment 1, dual-task preference scores were based on those trials in which participants produced the correct button-press pattern. Participants were very accurate in performing the finger patterns ($M = 90\%$, $SE = 1.6\%$); thus, including all trials would not have changed the pattern of results.

Preference Judgments

A 2 (typing expertise: novice, skilled) × 2 (block: single-task, dual-task) analysis of variance on preference judgments revealed no main effect of block, $F < 1$, and no Block × Expertise interaction, $F(1, 40) = 1.52$, $p = .23$ (Fig. 2). There was, however, a significant main effect of expertise, $F(1, 40) = 4.90$, $p < .04$, $p_{\text{rep}} = .90$, $\eta^2 = .11$. This main effect reflects the fact that across both the single- and the dual-task blocks, novices' preferences did not significantly differ from chance, $t(21) < 1$, whereas experts' preferences did, $t(19) = 3.28$, $p < .01$, $p_{\text{rep}} = .98$, $d = 1.09$. When skilled typists were forced to hold in memory a motor plan that did not involve the fingers that would be used to type the presented letter dyads, their preference for dyads that did not create motor interference remained.

Typing Rule

No one was able to determine the difference between the two columns of letter dyads.

Discussion

As in Experiment 1, skilled typists preferred letter dyads that, if typed, would create the least motor interference. Novices showed no preference. Critically, unlike in Experiment 1, skilled typists maintained their preference when they held in memory a motor plan that did not involve the fingers that would be used to type the presented dyads. Not only does covert sensorimotor simulation of typing the letters affect skilled typists' preference judgments, but this simulation appears to be digit-specific.

GENERAL DISCUSSION

Two experiments tested the hypothesis that perceiving letter dyads prompts covert sensorimotor simulation of typing the dyads, thereby providing affective information about them—provided one has typing experience that results in associations between the specific letters and the motor programs used to type them (Rieger, 2004). Novice and skilled typists were presented with paired letter dyads—one dyad typed with the same finger using traditional typing methods and the other typed with different fingers. Although skilled typists preferred letter dyads that, if typed, would produce the least motor interference, novices showed no preference (see also Van den Bergh et al., 1990). To demonstrate that typists' preference was indeed due to sensorimotor simulation of typing the dyads, we asked participants to perform the preference task while holding a motor plan in memory. When the motor plan involved the fingers that would be used to type the presented dyads, skilled typists' preference was attenuated. When the motor plan involved effectors different from those the dyads demanded (i.e., fingers not used to type the dyads), the preference remained. Covert sensorimotor simulation of typing the presented letters appears to be specific to the effectors involved in acting on those letters.

It is not likely that these effects were due to skilled typists' familiarity with the letter dyads, as the dyads formed extremely low-frequency combinations in the English language, and combination frequency did not differ between same-finger and different-fingers dyads. In addition, a frequency explanation cannot account for why a motor task involving the fingers that would be used to type the dyads eliminated skilled typists' preference, but a motor task involving fingers not used to type the dyads did not. Rather, the best account of these results is that sensorimotor simulation of typing the letter dyads provided information about motor interference that produced preference for one dyad over another. Moreover, the fact that typists could not identify the difference between same-finger and different-fingers dyads suggests that such simulation is covert.

We specifically designed the dyads so that they differed as a function of motor interference if typed—thus exploiting differences between letter-action associations in skilled and novice typists. It may also be the case that presenting the letters on a computer enhanced the implicit association between the letters and typing movements. What would happen if the letters were presented in a way that limited such associations? For example, if letters presented in participants' own handwriting prompt the covert sensorimotor simulation of writing (Knoblich et al., 2002), one might see very different results. First, typing skill would not be expected to interact with preference judgments, as skilled and novice typists presumably have the same amount of writing experience. Second, individuals would likely prefer those letter combinations that cause less motor interference to write, rather than to type. Thus, the way in which one covertly simulates acting on stimuli in the environment, and the resulting affective judgments such simulation renders, is likely dependent on one's experience in a given domain and the most salient features of what one perceives (Calvo-Merino, Glaser, Grezes, Passingham, & Haggard, 2005; Holt & Beilock, 2006).

Sensorimotor simulation is thought to contribute to the representation of actions and of objects on which one might act (Garbarini & Adenzato, 2004). Our work demonstrates that the body not only contributes to understanding, but also shapes affective judgments. Moreover, research has shown that overtly behaving in ways consistent with positive or negative affective states (e.g., facilitating or inhibiting the muscles typically associated with smiling without actually posing in a smiling face because one is, for example, asked to hold a pen in one's mouth in a particular way) influences emotional responses in ways congruent with the motor behavior (Strack, Martin, & Stepper, 1988). We have shown that such movements are not necessary to influence affect. Covert sensorimotor simulation of acting on stimuli can afford affective information, even when individuals have no intention to act—as long as they have developed relevant associations between what they perceive and how it can be acted on. In conclusion, the current experiments extend previous work demonstrating how the body influences understanding of objects and events, showing that this influence applies to affective judgments about the information one encounters.

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