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Alignment Effects for Pictured Objects: Do Instructions to "Imagine Picking Up an Object" Prime Actions?

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Research suggests that responses to pictures of manipulable objects are facilitated when the location of the response is aligned with the side of the object handle. One interpretation of alignment effects is that object identification results in the automatic activation of actions associated with the object. Alignment effects are, however, not ubiquitously found. Yu, Abrams, and Zacks (2014) found an alignment effect when participants were instructed to imagine picking up the pictured objects while making upright-inverted judgments. Six other experiments, which did not use such instructions, found no alignment effect. One interpretation is that motor-imagery instructions draw attention to the graspable parts of an object, which results in the activation of actions associated with the object. This account predicts that alignment effects are restricted to responses with the left and right hand. An alternative interpretation is that motor-imagery instructions result in the formation of abstract spatial codes for left versus right. This spatial coding account predicts that alignment effects are present for other types of responses that involve a left-right dimension. Consistent with the latter account, we found that alignment effects were found even when participants responded with the index and middle finger of the same hand or with their left and right feet.

Public Significance Statement

Currently popular accounts of human cognition suggest that the actions associated with objects are automatically activated when one perceives an object. Our study presents evidence against this view. In fact, it suggests that not even when participants are instructed to think how they would pick up an object is such information readily activated.

Keywords: alignment effect, affordance, spatial coding, stimulus response compatibility, action priming, motor imagery

It has been suggested that the identification of an object results in the activation of the actions afforded by the object even in the absence of an intention to interact with the object. Evidence consistent with this view comes from studies investigating alignment and grasp compatibility effects (for recent reviews, see Osiurak & Badets, 2016; Proctor & Miles, 2014). Tucker and Ellis (1998) presented images of graspable objects with their handles located on either the right or the left, and participants responded via button presses to the upright/inverted orientation of the objects. Responses were faster when the location of the object handle and the response hand were aligned (e.g., object handle located on the right, response with the right hand) than when they were misaligned (e.g., object handle located on the left, response with the right hand). An alignment effect was obtained even though mapping of object orientation (upright/inverted) to response hand (left/right) was counterbalanced across participants and the location of the object handle was task irrelevant. Subsequent studies (e.g., Tucker & Ellis, 2001) showed faster responses when the grasp afforded by the object (precision vs. power) was compatible with the response grasp than when it was incompatible. These and other findings (Derbyshire, Ellis, & Tucker, 2006; Ellis & Tucker, 2000; Glover, Rosenbaum, Graham, & Dixon, 2004; Lee, Middleton, Mirman, Kalénine, & Buxbaum, 2013) led to the conclusion that object identification results in the automatic activation of actions afforded by the object, facilitating responses when aligned with the handle side. This interpretation is referred to as the affordance view.

Recent studies, however, indicate that there are some problems with the affordance view. One problem is that alignment effects are also found under circumstances when no such effect is predicted by the affordance view. For example, Cho and Proctor

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(2010) found alignment effects not only when participants responded with the index fingers of the left and right hand (between-hand condition) but also when they responded with the index and middle fingers of the right hand (within-hand condition). In another study, Phillips and Ward (2002) found alignment effects when participants responded with their left and right feet. These alignment effects, obtained when participants responded with different fingers of the same hand or when they responded with their feet, are inconsistent with predictions of the affordance view. According to the affordance view, alignment effects are explained by the activation of actions that prime the congruent response. Therefore, it is not consistent with this view that presented objects can differentially prime or activate different fingers on the same hand or that the objects differentially activate the left and right feet. Cho and Proctor (2010, 2011; also see Proctor & Miles, 2014) argue that alignment effects are best explained by relative location coding. According to this account, spatial response codes and spatial stimulus codes are formed when both stimuli and responses have a spatial (e.g., left-right) dimension. When the spatial codes for stimulus and response correspond, that is, when the object handle and response are aligned (e.g., both located on the right), this results in faster and more accurate responses than when the codes do not correspond. In effect, according to this account, alignment effects are a variation of the well-known Simon effect.

Another problem with the affordance view is that handled objects do not consistently elicit alignment effects. Rather, the presence (and direction) of alignment effects is affected by stimulus characteristics, task requirements, and instructions. For example, Cho and Proctor (2011) investigated alignment effects for a pictured teapot. They found an alignment effect with respect to the spout rather than the handle (or, stated differently, a negative alignment with respect to the handle). Cho and Proctor argued that the alignment effect was driven by the most spatially salient location component, the spout, rather than the graspable part, the handle. When the spout was removed from the pictured teapot, so that the handle was the most spatially salient location component, an alignment effect with respect to the handle was observed. In a subsequent experiment, Cho and Proctor found no alignment effect for pictured door handles in an object-centered condition in which the entire object was centered on the screen. However, an alignment effect was present in the base-centered condition in which the base of the door handle was centered on the screen and the handle protruded to the left or the right. Together, these results suggest that the alignment effect is not driven by the actions afforded by the object but rather by spatially salient protrusions located on the left or the right of the object.

Other studies have also failed to find alignment effects for object-centered images of graspable objects. Bub and Masson (2010) did not find alignment effects for object-centered beer mugs when participants made button presses (Experiment 2) but did find the effect for the same stimuli when participants made reach and grasp movements (Experiment 1). Finally, Yu, Abrams, and Zacks (2014) similarly found no alignment effects toward object handles in six different experiments. Rather than presenting a single object repeatedly throughout the experiment, Yu et al. presented a large number of images of different objects (e.g., cup, can, drill, fork, hammer). Although no alignment effect was found under standard instructions, Yu et al. did find an alignment effect when participants were instructed to "think about picking up the objects presented on the screen." The findings of Bub and Masson and Yu et al. thus indicate that alignment effects of object-centered stimuli can be found when the context emphasizes actions either by requiring participants to perform reach and grasp movements or by giving motor-imagery instructions that require participants to imagine picking up the depicted objects. Although much research has been done with reach and grasp movements and the alignment effect, Yu et al. are the first to present these findings in relation to the use of explicit motor-imagery instructions. The present study therefore aimed to investigate the processes responsible for alignment effects under motor-imagery instructions.

One possible explanation for the presence of an alignment effect under motor-imagery instructions is that these instructions result in the activation of actions associated with the depicted object. Motor-imagery instructions may cause participants to focus attention on the object handle, which in turn may activate the action representations that are associated with the object. Such action representations may specify the hand (left or right) and specific type of grasp (e.g., power grasp, precision grasp) afforded by the object. Additionally, motor-imagery instructions may cause participants to retrieve past experiences manipulating these objects, which may also result in the activation of action representations. Research has suggested that the brain areas activated during motor-imagery partially overlap with those active during actual movements (Ehrsson, Geyer, & Naito, 2003; Gerardin et al., 2000; Lotze et al., 1999). Thus, it is possible that motor-imagery instructions elicit the type of processes envisioned by proponents of the affordance view.

An alternative view is that motor-imagery instructions induce relative location coding. As mentioned, Proctor and colleagues (Cho & Proctor, 2010, 2011; Proctor & Miles, 2014) have argued that alignment effects are driven by abstract spatial codes. These codes are considered abstract in the sense that they are not modality specific and are not linked to a specific motor action. Such codes will be formed when objects have spatially salient components. However, when an object has no clear protrusions or when it has protrusions on both sides of the object (e.g., a spout and a handle), there may be no spatial codes formed or codes formed may be inconsistent and varying between trials and participants. In such cases, no alignment effect will be observed, according to the abstract spatial coding view. Motor-imagery instructions might draw attention to the object handle causing the formation of more consistent relative location codes. In other words, by instructing participants to imagine picking up the object, attention may be focused on the object handle, in turn causing the generation of a consistent relative location code for left or right (depending on the location of the handle).

The present study aimed to investigate which view, the affordance view or the abstract spatial coding view, provides the best explanation of alignment effects when motor-imagery instructions are given. We first wanted to investigate whether we could replicate the main findings of Yu et al. (2014). In Experiment 1, we presented the same object pictures used by Yu et al. in an upright/inverted decision task, with no motor-imagery instructions given. Accordingly, we expected that no alignment effect would be present, just as in the six experiments of Yu et al. when there were no specific motor-imagery instructions given. In Experiment 2, we gave the motor-imagery instruction of Yu et al.'s Experiment 3b, and similarly, we expected to find an alignment effect.

The main question addressed in Experiments 3 and 4 is whether motor-imagery instructions induce an affordance effect or induce the formation of an abstract spatial code for left versus right by drawing attention to the (location of) the object handle. This question is addressed in Experiment 3 by having participants respond with two fingers of the same hand. Following the experiments of Cho and Proctor (2011), participants used the index and middle fingers of their right hand to respond. The affordance account would predict an alignment effect only when participants respond with the left or right hand but not when they respond with the index or middle finger of the same hand. In contrast, an abstract spatial coding account predicts an alignment effect also in the within-hand response condition because the left-right dimension in the response set is preserved. We further test the predictions of these accounts in Experiment 4 by having participants respond with their feet. Again, an alignment effect would be predicted by an abstract spatial coding account when participants respond with their feet, but an affordance account would predict no alignment effect.

Experiment 1

Method

Participants. A sample size of 60 participants was used in all experiments reported here. According to G*Power (Faul, Erdfelder, Buchner, & Lang, 2009), a sample size of 34 is needed for a power of .80 and a sample size of 54 is needed for a power of .95, assuming an effect size of $d = .50$ (using two-sided paired-samples t tests with $\alpha = .05$). In this and subsequent experiments, all participants were psychology students at Erasmus University Rotterdam participating either voluntarily (i.e., without compensation) or for course credit.[1] No one participated in more than one of the experiments reported in this article. The results of 60 participants are reported here. Three additional participants were tested, but their data were not included in the analyses; the first two participants were used as pilot participants and a third participant received the incorrect version of the experiment.

Apparatus. Stimuli were presented on a 22-in. computer monitor via the program E-prime, Version 2.0 (Psychology Software Tools, Pittsburgh, PA). The resolution of the display was set to 1,920 × 1,200. The monitor was placed at an approximate distance of 60 cm from each participant, with the response keyboard located roughly 30 cm in front of the display.

Stimulus materials and procedure. We used the original pictures of Yu et al. (2014), Experiments 3a and 3b). These consisted of 22 pictures of manmade objects that were flipped vertically for right and left handle orientations and horizontally for upright and inverted orientations. This resulted in four variations of each object. Each variation of each object was presented once in each of the six blocks, creating 88 trials in each block. An additional set of six practice pictures depicted different objects and were each flipped horizontally to create 6 upright and 6 inverted versions for 12 practice trials. Finally, one more object picture was used for instruction to show an upright and inverted object. Pictures showed the object from the side and slightly from above so that the overall shape of the object, including the handle, was clearly visible. See Appendix for a listing of all critical stimuli (Figure A1). Images were centered on the screen and spanned approximately 14 to 29 degrees of visual angle at the viewing distance of 60 cm, in attempt to appear roughly life sized.

Experiment 1 followed the same structure as Experiment 3b of Yu et al. (2014), except that no motor-imagery instructions were given. Upon arrival, on-screen instructions were shown to participants and the experimenter ensured that the procedure was clear to participants before beginning. An opportunity to ask questions was provided.

Prior to the main experiment, participants completed a set of 12 practice trials containing six objects, which were either upright or inverted. Here, they were simply required to respond as to whether the object was upright or inverted using the buttons allocated on the instruction screens. Prior to the practice trials, participants were given the specific instructions from Yu et al.'s (2014) Experiment 3b. Before the experimental trials began, a message appeared reminding participants which hand to use for which response. Half of all trials in one block had aligned response hand and handle location, whereas the remaining trials were misaligned. During both practice and experimental blocks, stimuli were presented in random order. Different random orders were generated for each block and each participant.

At the beginning of each trial, a fixation cross was presented for 1,500 ms, followed by an interstimulus interval of 250 ms, and then one of the randomly selected object pictures. The object was displayed on screen until a response was made. Participants were required to respond via the "m" and "z" keys on the keyboard, which corresponded to an object being upright or inverted. Key assignment was counterbalanced across participants; half of the participants responded with "m" to upright objects and "z" to inverted ones; the other half responded with the opposite key assignment. Participants were required to keep their fingers on the response buttons at all times during the trials to ensure responding as fast as possible.

Feedback was given only when participants made an error, in which case a message "wrong hand" appeared on screen for 1,500 ms. Following the response of each object, an interval of 1,000 ms occurred before the start of the new trial. At the end of each block, a message appeared, which allowed participants to take a short screen break before continuing to the next set of trials in the next block.

Analyses. Reaction times (RTs) and error rates were measured for aligned and misaligned trials for each participant, which were compared using paired sample t tests. Error rates were calculated by the percentage of trials incorrectly judged as upright or inverted. Aligned trials were defined as those where the correct response button was on the same side of the screen as the handle of the object on screen, whereas misaligned trials were defined as those in which the correct response button was on the opposite side of the location of the object handle on screen.

In addition to calculating p values, we calculated the Jeffreys, Zellner and Siow (JZS) Bayes factor (BF), which is the ratio of $p(D|H_0)$ and $p(D|H_1)$, that is, the probabilities of observing the data under the null hypothesis and the alternative hypothesis, respectively. The BF thus provides a relative measure of the extent to

[1] We did ask participants to report age and gender in Experiments 2–4 but not Experiment 1. The participants in Experiment 1, however, were sampled from the same general subject pool as those in Experiments 2–4.

which the data provide evidence for the null hypothesis of no effect or the alternative hypothesis (Rouder, Speckman, Sun, Morey, & Iverson, 2009). BFs < 3 are said to provide "anecdotal evidence," BFs > 3 and <10 are said to provide "moderate evidence," BFs > 10 are said to provide "strong evidence," and BFs > 30 are said to provide "very strong evidence." BFs were calculated using JASP (Love et al., 2015). All Bayesian t tests were performed with directional hypotheses and a Cauchy prior width of 0.707. Throughout this article, we report $BF_{0/1}$ if the evidence is in favor of H_0 and $BF_{1/0}$ if the evidence is in favor of H_1.

Results and Discussion

We used the same outlier criteria as Yu et al. (2014), who excluded responses that were faster than 300 ms or slower than two standard deviations above the participant's mean. The same outlier criteria were used for all experiments. After trimming the data, 4.50% of trials were excluded due to error, and a further 4.39% were removed as outlying trials. The results are shown in Table 1. The RTs did not differ between alignment conditions, $t(59) = 1.14$, $p = .257$, Cohen's $d = 0.15$, $BF_{0/1} = 2.20$, but participants made fewer errors in the aligned than in the misaligned condition, $t(59) = 2.03$, $p = .047$, Cohen's $d = 0.26$, $BF_{1/0} = 1.85$. Thus, the results partially replicate Yu et al.'s findings. Similar to Yu et al., we also did not obtain an alignment effect in the RTs, but there was a small effect in the error rates.

Experiment 2

Experiment 2 is a replication of Yu et al.'s (2014) Experiment 3b, in which an alignment effect was found when participants were instructed to think about picking up the objects presented on screen before responding. Here, we examined whether this finding could be replicated in our lab.

Method

Participants. The results of 60 participants are reported here. Six additional participants were tested, but their data were not included in the analyses. Conforming to the methods of Yu et al. (2014), two of these participants were excluded because they indicated that they could not imagine picking up the object while performing the upright decision task. Another participant was excluded because of hardware malfunction, and a further three were excluded to maintain a properly counterbalanced design.[2] Fifty-six participants were right-handed and 52 were female. The age of participants ranged between 17 and 41 years ($M = 20.55$).

Table 1
Reaction Times in Milliseconds and Percent Errors (SE in Parentheses) in Experiment 1

Condition	RT	PE
Aligned	711 (19)	4.15 (.48)
Misaligned	714 (19)	4.85 (.50)
Alignment effect	3 (3)	.70 (.34)

Note. No motor-imagery instructions were given. RT = reaction time; PE = percent error.

Apparatus, stimulus materials, and procedure. The experiment was identical to Experiment 1, except that motor-imagery instruction was given to the participants. Thus, the same explicit instruction as in Yu et al. (2014, Experiment 3b) to "think about picking up each object when it appeared on the screen," as part of the strategy for making the upright/inverted judgments, was also used here. After each block, the participant was asked whether he or she was able to imagine picking up each object (yes/no report). As in Yu et al. (2014), participants who were unable to do so were excluded from the analyses. After completing the experiment, participants were asked some short demographic questions about their age, gender, native language, and handedness.

Results and Discussion

After trimming the data, 3.38% of trials were excluded because of response error, and a further 4.41% were removed as outlying trials. The results are shown in Table 2. A significant alignment effect was observed for RTs, $t(59) = 4.35$, $p < .001$, Cohen's $d = 0.56$, $BF_{1/0} = 759$. This effect was also observed in the error rates, $t(59) = 4.31$, $p < .001$, Cohen's $d = 0.56$, $BF_{1/0} = 677$. Thus, responses were faster and more accurate when the response hand was aligned with the side of the object handle, compared to when the response hand was not aligned with the side of the object handle.

To investigate if the results from Experiments 1 and 2 differed, we combined the data and performed a mixed 2 (experiment) $\times$ 2 (alignment) analysis of variance. For the RTs, there was no main effect of experiment, $F(1, 118) < 1$, $p = .487$, partial $\eta^2 = .00$, and a significant interaction between experiment and alignment, $F(1, 118) = 6.26$, $p = .014$, partial $\eta^2 = .05$, which confirms that the alignment effect was influenced by the motor-imagery instructions. The interaction was also tested as a directional Bayesian paired-samples t test on the difference (between experiments) of the differences (aligned minus unaligned conditions), $BF_{1/0} = 6.24$.

For the error rates, we obtained a main effect of experiment, $F(1, 118) = 3.94$, $p = .050$, partial $\eta^2 = .03$, but no interaction between experiment and alignment, $F(1, 118) = 1.10$, $p = .297$, partial $\eta^2 = .01$, $BF_{0/1} = 9.77$.

Experiment 3

To investigate which explanation better accounts for the alignment effect found here and in Yu et al. (2014, Experiment 3b), we changed the response mode in Experiment 3 so that participants used the index and middle fingers of their right hand to respond, similar to the within-hand condition of Cho and Proctor (2011). If the alignment effect observed in Experiment 2, with instructions to imagine picking up the object, occurs because of an affordance effect (Tucker & Ellis, 1998), it would be expected that no effect is observed when responses are made using one hand. This is because action priming would facilitate responding with the aligned hand, in comparison with the misaligned hand. In this experiment, however, only one hand is used. The affordance view would not expect objects to prime differentially between actions of the index and

[2] Removal was based on order of testing. We removed the final participants tested in a counterbalanced version.

Table 2
Reaction Times in Milliseconds and Percent Errors (SE in Parentheses) in Experiments 2–4

Condition	Experiment 2		Experiment 3		Experiment 4	
	RT	PE	RT	PE	RT	PE
Aligned	726 (23)	2.81 (.29)	806 (24)	2.70 (.26)	1,005 (37)	1.43 (.18)
Misaligned	739 (23)	3.96 (.41)	820 (24)	3.53 (.32)	1,029 (38)	2.34 (.27)
Alignment effect	13 (3)	1.15 (.27)	14 (4)	.83 (.25)	24 (5)	.91 (.19)

Note. Motor-imagery instructions were given in Experiments 2–4. RT = reaction time; PE = percent error.

middle fingers of the same hand (Cho & Proctor, 2010; Tucker & Ellis, 1998) but instead would predict alignment effects to be observed when participants use their right or left hand to respond. In contrast, if the motor-imagery instructions increase attention to object handles, thereby inducing abstract spatial coding for left and right (Cho & Proctor, 2011), an alignment effect just as in Experiment 2 would be expected.

Method

Participants. The results of 60 participants are reported here. Five additional participants were tested, but their data were not included in the analyses; three participants were excluded due to not using only the right hand to respond, and a further two said they could not imagine picking up the objects. Fifty-seven participants were right-handed and 45 were female, with the age ranging between 18 and 25 years ($M = 20.85$).

Apparatus, stimulus materials, and procedure. All apparatus and stimuli were the same as in Experiments 1 and 2. The only difference was that participants were required to respond via the "b" and "n" keys on the keyboard with the index and middle fingers of only their right hand. The assignment of finger (index/middle) to orientation (upright/inverted) was counterbalanced across participants.

The same explicit instructions to think about picking up each object before responding with the index or middle finger of their right hand was also used. At the end of the experiment, the participants were asked whether they were able to imagine picking up each object, as well as whether they always used their right hand to respond as instructed.

Results and Discussion

As in previous experiments, comparisons between aligned and misaligned trials were conducted by paired-samples t tests for RTs and error rates. Before this, 3.10% of trials were excluded because of response error, and a further 4.06% were removed as outlying trials. The results are shown in Table 2. As in Experiment 2, a significant alignment effect was observed for RTs, $t(59) = 3.55$, $p = .001$, Cohen's $d = 0.46$, $BF_{1/0} = 68.02$, and error rates, $t(59) = 3.28$, $p = .002$, Cohen's $d = 0.42$, $BF_{1/0} = 32.07$. These results show that even when participants responded by using the index and middle fingers of the same hand, responses were still faster and more accurate when the location of the button press (left/right) was aligned with spatial location of the object handle, compared to when they were misaligned.

Our results support the explanation that the alignment effects observed here can be attributed to an attentional process, rather than an affordance one. The action representation that was assumed to be activated by passive viewing of an object (Tucker & Ellis, 1998) is not compatible with the within-hand response required by the task. The alignment effect observed can therefore better be attributed to an abstract coding one, as there was a facilitation of responses when the spatial coding of both buttons pressed by the right hand was aligned with the spatial positioning of the handle. We can conclude that the effect can be observed with the explicit instruction to think about picking up the object because this is what drives attention toward the graspable part, producing a strong spatial code relative to its position, and facilitating response when its location is aligned with the location of response.

Experiment 4

To provide additional evidence for our proposal that alignment effects under motor-imagery instructions are best explained by a spatial coding account, participants responded with foot pedals in Experiment 4. If the instruction to imagine picking up the object on the screen resulted in the activation of affordances, we would predict no alignment effect in Experiment 4. If, however, these instructions resulted in the formation of an abstract spatial code relative to the handle location, we would predict an alignment effect even when participants respond with their feet.

Method

Participants. The results of 60 participants are reported here. Three additional participants were tested, but their data were not included in the analyses because they reported that they could not imagine picking up the objects. Fifty-four participants were right-handed and 49 were female, with the age ranging between 18 and 37 years ($M = 19.92$).

Apparatus, stimulus materials, and procedure. Almost all aspects of the methods were identical to that of Experiments 2 and 3. The only difference was that participants were required to respond with foot pedals. The foot pedals are shown in Figure 1. The assignment of foot pedal (left/right) to object orientation (upright/inverted) was counterbalanced across participants. That is, half of the participants pressed the right pedal for upright object pictures and the left pedal for inverted object pictures. The opposite assignment was used for the other participants.

The same explicit instruction was given to think about picking up each object before responding with their feet and was again checked at the end of the experiment as to whether they followed this instruction.

Figure 1. Foot pedals used in Experiment 4. See the online article for the color version of this figure.

Results and Discussion

Again, comparisons between aligned and misaligned trials were conducted by paired-samples *t* tests for RTs and error rates. Before this, 1.88% of trials were excluded because of response error, and a further 4.14% were removed as outlying trials. The results are shown in Table 2. As in Experiments 2 and 3, a significant alignment effect was observed for RTs, $t(59) = 4.60$, $p < .001$, Cohen's $d = 0.59$, $BF_{1/0} = 1686$, and error rates, $t(59) = 4.81$, $p < .001$, Cohen's $d = 0.62$, $BF_{1/0} = 3367$. Thus, even when participants used their feet to respond, responses were faster and more accurate when the location of the foot pedal press (left/right) was aligned with spatial location of the object handle, compared to when they were misaligned.

General Discussion

The goal of this study was to investigate which account, the affordance account or the spatial coding account, provides the best explanation of alignment effects. In Experiment 1, we presented object pictures from Yu et al. (2014) with the handle on the left or on the right. Participants decided whether pictured objects were presented upright or inverted (i.e., upside down). We investigated whether participants would respond faster if the object handle and correct response hand were aligned (e.g., object handle on the right, correct response with the right hand) compared to when object handle and response hand were misaligned (e.g., object handle on the left, correct response with the right hand). No alignment effect in RTs was found in Experiment 1, although there was a small effect in the error rates. Experiment 2 was a replication of Yu et al.'s (2014), Experiment 3B) using specific task demands to think about picking up the object. Like Yu et al., our results showed faster RTs and lower error rates when the response hand was aligned with the object handle. An additional analysis on the combined results of Experiments 1 and 2 showed a significant interaction between alignment and experiment, indicating that motor-imagery instructions modulated the alignment effect.

The finding of an alignment effect when participants received motor-imagery instructions could be due to an instruction-induced affordance effect. That is, the instructions may have made the affordances of the objects more salient. These object affordances, in turn, may have resulted in the partial activation of a grasping response toward the depicted objects; the activated information may have included information about the arm (left vs. right) to reach for an object and the specific shape of the hand necessary to grasp the object. The specific information that is activated would facilitate responses that are compatible with the primed action. Thus, according to this view, if an object with the handle oriented to the right primes an action with the right hand, participants would be faster to respond with the right hand than with the left hand.

An alternative explanation of the alignment effect found in Experiment 2 is that the instruction to imagine picking up the pictured object on screen was responsible for the generation of abstract spatial codes, because they may have directed attention toward the object handle. So, if the object handle is oriented to the left, then an abstract spatial code for "left" will be generated, and if the object handle is oriented to the right, then an abstract spatial code for "right" will be generated. Under this assumption, left-right spatial codes are generated because the instructions induce participants to attend to the location of the handle. If there are no instructions to imagine picking up the object, left-right spatial codes are not generated.[3]

Experiment 3 tested these accounts by requiring participants to respond with the index and middle fingers of the same hand. The affordance account would predict no alignment effect in this experiment because the actions primed by the object do not differentiate between the index and middle fingers of the same hand (Cho & Proctor, 2010; Tucker & Ellis, 1998). It would be reasonable to expect that the actions primed by the instruction to "imagine picking up the object" would also not differentiate between the two fingers, since you would never need to select between either finger in order to pick up one of these objects. The abstract spatial coding account, however, would predict an alignment effect when participants respond with their index and middle fingers because this preserves the left-right dimension in the response set. Our results show that an alignment effect was in fact present in Experiment 3. Additional evidence for the spatial coding account was obtained in Experiment 4 in which participants responded with their left and right feet. Together, Experiments 3 and 4 indicated

[3] Alternatively, abstract spatial codes may be formed by attending to other features of an object, but they may not always correspond with the side of the handle, for example, when an object has a protrusion on the side opposite to the handle.

that alignment effects under motor-imagery instructions are not due to the priming of actions that correspond to those performed by the participant. Rather, these are based on abstract spatial codes.

The results of Yu et al. (2014) and the present study indicate that motor-imagery instructions have an influence on alignment effects. Other findings reported in the literature also suggest that context can modulate alignment effects. Yu et al. (2014) noted that Tucker and Ellis (1998) used instructions that may have inadvertently invited participants to imagine actions with the displayed objects. This may explain why Tucker and Ellis (1998) obtained alignment effects in their experiment, whereas the six experiments of Yu et al. that did not use motor-imagery instructions did not. In a comprehensive review of such alignment effects, Osiurak and Badets (2016) point to a number of contextual factors that influence the nature of effects, namely, depth information or information directing attention. Under presence of the latter, the authors concluded that alignment effects were most likely explained by attentional and spatial coding strategies. Finally, we note that Bub and Masson (2010) found no alignment effect when participants responded by making left or right keypresses to the color of a displayed object. However, when participants responded to the color of the object by making reach and grasp movements to a response element that they needed to grasp, an alignment effect was found. We are not arguing that motor-imagery instructions, videos showing interactions with objects, and reach and grasp responses necessarily affect alignment effects in the same manner. Motor-imagery instructions may have different effects on cognitive processes than performing actual reach and grasp movements toward response elements. Nevertheless, these results do all suggest that contexts that contain references to actions are more likely to elicit alignment effects.

We should point out that alignment effects have also been found even when the experimental context does not emphasize actions. Cho and Proctor (2010) found robust alignment effects for body-centered frying pans with the handle located to the left or the right of the body. Participants responded with button presses to the color (Experiment 1) or upright/inverted orientation (Experiments 2 and 3) of the frying pan. No motor-imagery instructions were given and no videos of people performing actions on objects were shown in the experiment. Likewise, Cho and Proctor (2011) found an alignment effect for door-handle stimuli when the base of the door handle was centered on the screen so that the handle protruded to the left of the right. No alignment effect was found, however, in the handle-centered condition in which the entire door handle (including base) was centered on the screen. Again, no motor-imagery instructions were given and no videos of people performing actions were shown to participants. Thus, it seems that robust alignment effects can be found for stimuli with visually salient components on the left or right side of the object. These stimuli induce the formation of consistent left-right codes in the absence of instructions or videos that emphasize actions and direct attention to object handles. Another class of stimuli, those without clear protrusions or visually salient components on one side of the object, only show robust alignment effects when the experimental context emphasizes actions and thereby focuses attention on object handles. In the present study, we examined alignment effects for those kinds of objects. Motor-imagery instructions do consistently elicit alignment effect for these stimuli, but as explained before, these effects are best explained by the abstract spatial coding account rather than the affordance account.

A recent study by Roest, Pecher, Naeije, and Zeelenberg (2016), using the reach and grasp procedure developed by Bub and Masson (2010), also found evidence consistent with an abstract spatial coding account of alignment effects. Participants in the Roest et al. study performed the regular two-choice task and a go/no-go version of the task. In the regular two-choice task, participants responded to one stimulus property (e.g., upright orientation) with the left hand and to the other property (e.g., inverted orientation) with the right hand. In the go/no-go task, participants made responses with one hand (e.g., the left hand) to only one stimulus property (e.g., upright orientation) and did not respond to the other stimulus property (e.g., inverted orientation). In the regular two-choice task, Roest et al. found an alignment effect, but in the go/no-go version, no alignment effect was present. The absence of an alignment effect in the go/no-go task is consistent with earlier results obtained with a standard Simon task, in which participants made color decisions to red or green disks presented left or right of the screen center (Ansorge & Wühr, 2004). The abstract spatial coding account predicts no alignment effect when the left-right dimension is eliminated from the response set, as was the case in the Roest et al. study in which participants responded with only one hand and never used the other hand to respond (for related findings, see Pecher, Roest, & Zeelenberg, in press). Thus, the results of different paradigms converge to suggest that the spatial coding viewing provides a viable account of alignment effects.

Summary and Conclusion

Alignments effects have traditionally been taken to indicate that the perception of an object results in the automatic activation of the actions associated with the object. Recent studies suggest that alignment effects are affected by specific stimulus characteristics and instructions given to participants, questioning the automatic nature the activation of affordances. Most relevant for the present study, Yu et al. (2014) recently showed that alignment effects were present when participants received motor-imagery instructions that were absent when no such instructions were given. Here we show that such motor-imagery instructions do not elicit the activation of specific actions associated with the objects but rather generate an abstract spatial code for the left-right location of the graspable part of an object.

References

Ansorge, U., & Wühr, P. (2004). A response-discrimination account of the Simon effect. *Journal of Experimental Psychology: Human Perception and Performance, 30,* 365–377. http://dx.doi.org/10.1037/0096-1523.30.2.365

Bub, D. N., & Masson, M. E. (2010). Grasping beer mugs: On the dynamics of alignment effects induced by handled objects. *Journal of Experimental Psychology: Human Perception and Performance, 36,* 341–358. http://dx.doi.org/10.1037/a0017606

Cho, D. T., & Proctor, R. W. (2010). The object-based Simon effect: Grasping affordance or relative location of the graspable part? *Journal of Experimental Psychology: Human Perception and Performance, 36,* 853–861. http://dx.doi.org/10.1037/a0019328

Cho, D. T., & Proctor, R. W. (2011). Correspondence effects for objects with opposing left and right protrusions. *Journal of Experimental Psychology: Human Perception and Performance, 37,* 737–749. http://dx.doi.org/10.1037/a0021934

Derbyshire, N., Ellis, R., & Tucker, M. (2006). The potentiation of two components of the reach-to-grasp action during object categorisation in visual memory. *Acta Psychologica, 122,* 74–98. http://dx.doi.org/10.1016/j.actpsy.2005.10.004

Ehrsson, H. H., Geyer, S., & Naito, E. (2003). Imagery of voluntary movement of fingers, toes, and tongue activates corresponding body-part-specific motor representations. *Journal of Neurophysiology, 90,* 3304–3316. http://dx.doi.org/10.1152/jn.01113.2002

Ellis, R., & Tucker, M. (2000). Micro-affordance: The potentiation of components of action by seen objects. *British Journal of Psychology, 91,* 451–471. http://dx.doi.org/10.1348/000712600161934

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41,* 1149–1160. http://dx.doi.org/10.3758/BRM.41.4.1149

Gerardin, E., Sirigu, A., Lehéricy, S., Poline, J. B., Gaymard, B., Marsault, C., . . . Le Bihan, D. (2000). Partially overlapping neural networks for real and imagined hand movements. *Cerebral Cortex, 10,* 1093–1104. http://dx.doi.org/10.1093/cercor/10.11.1093

Glover, S., Rosenbaum, D. A., Graham, J., & Dixon, P. (2004). Grasping the meaning of words. *Experimental Brain Research, 154,* 103–108. http://dx.doi.org/10.1007/s00221-003-1659-2

Lee, C. L., Middleton, E., Mirman, D., Kalénine, S., & Buxbaum, L. J. (2013). Incidental and context-responsive activation of structure- and function-based action features during object identification. *Journal of Experimental Psychology: Human Perception and Performance, 39,* 257–270. http://dx.doi.org/10.1037/a0027533

Lotze, M., Montoya, P., Erb, M., Hülsmann, E., Flor, H., Klose, U., . . . Grodd, W. (1999). Activation of cortical and cerebellar motor areas during executed and imagined hand movements: An fMRI study. *Journal of Cognitive Neuroscience, 11,* 491–501. http://dx.doi.org/10.1162/089892999563553

Love, J., Selker, R., Marsman, M., Jamil, T., Verhagen, A., Ly, A., . . . Wagenmakers, E.-J. (2015). JASP (Version 0.7.1) [Computer Software]. Retrieved from https://jasp-stats.org

Osiurak, F., & Badets, A. (2016). Tool use and affordance: Manipulation-based versus reasoning-based approaches. *Psychological Review, 123,* 534–568. http://dx.doi.org/10.1037/rev0000027

Pecher, D., Roest, S., & Zeelenberg, R. (in press). The effect of grasp compatibility in go/no-go and two-choice tasks. *Memory & Cognition*. http://dx.doi.org/10.3758/s13421-019-00917-5

Phillips, J. C., & Ward, R. (2002). SR correspondence effects of irrelevant visual affordance: Time course and specificity of response activation. *Visual Cognition, 9,* 540–558. http://dx.doi.org/10.1080/13506280143000575

Proctor, R. W., & Miles, J. D. (2014). Does the concept of affordance add anything to explanations of stimulus-response compatibility effects? In B. H. Ross (Ed.), *The psychology of learning and motivation* (Vol. 60, pp. 227–266). San Diego, CA: Academic Press.

Roest, S. A., Pecher, D., Naeije, L., & Zeelenberg, R. (2016). Alignment effects in beer mugs: Automatic action activation or response competition? *Attention, Perception, & Psychophysics, 78,* 1665–1680. http://dx.doi.org/10.3758/s13414-016-1130-7

Rouder, J. N., Speckman, P. L., Sun, D., Morey, R. D., & Iverson, G. (2009). Bayesian t tests for accepting and rejecting the null hypothesis. *Psychonomic Bulletin & Review, 16,* 225–237. http://dx.doi.org/10.3758/PBR.16.2.225

Tucker, M., & Ellis, R. (1998). On the relations between seen objects and components of potential actions. *Journal of Experimental Psychology: Human Perception and Performance, 24,* 830–846. http://dx.doi.org/10.1037/0096-1523.24.3.830

Tucker, M., & Ellis, R. (2001). The potentiation of grasp types during visual object categorization. *Visual Cognition, 8,* 769–800. http://dx.doi.org/10.1080/13506280042000144

Yu, A. B., Abrams, R. A., & Zacks, J. M. (2014). Limits on action priming by pictures of objects. *Journal of Experimental Psychology: Human Perception and Performance, 40,* 1861–1873. http://dx.doi.org/10.1037/a0037397

(*Appendix follows*)

Appendix

Stimuli Used in Experiments 1–4

Figure A1. Stimuli from Yu et al. (2014). See the online article for the color version of this figure.

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