Influencing Categorical Choices Through Physical Object Interaction

Nicholas J. Shipp (n.j.shipp@herts.ac.uk)
Department of Psychology, University of Hertfordshire
Hatfield, AL10 9AB, UNITED KINGDOM

Frédéric Vallée-Tourangeau (f.vallee-tourangeau@kingston.ac.uk)
Department of Psychology, Kingston University,
Kingston upon Thames, KT1 2EE, UNITED KINGDOM

Susan H. Anthony (s.h.1.anthony@herts.ac.uk)
Department of Psychology, University of Hertfordshire
Hatfield, AL10 9AB, UNITED KINGDOM

Abstract

Recent research has shown that action knowledge influences categorical decisions (Borghi, Flumini, Natraj & Wheaton, 2012; Chao & Martin, 2000; Iachini, Borghi & Senese, 2008; Kalénine, Shapiro, Flumini, Borghi & Buxbaum, 2013). Shipp, Vallée-Tourangeau, and Anthony, (2014) showed that action influences categorisation in a forced-choice triad task when combined with taxonomic information and presented within a functional context. The present experiment examined whether participants would be more likely to match items in a triad task based on shared actions following priming with the functional actions of the objects. Participants engaged in the triad task used in Shipp et al. after a priming phase where they either interacted with a series of objects for their functional capacity (Action Priming), grouped them into categories (Taxonomic Priming) or moved them from one table to another (Movement Priming). Items within the triads were presented as an image either on a white background (context-lean condition) or as a functional scene with the object being used by an agent (context-rich condition). Consistent with Shipp et al. the results showed that action was primarily used to base choices on the triad task when the action choice also shared a taxonomic relation, and was presented in context. Additionally, participants were more likely to select the action related item when they had been primed with the functional action of the objects. The results are discussed in terms of the transfer effect from the object interaction task that facilitates how the objects are simulated (Barsalou, 1999, 2003; Yeh & Barsalou, 2006).

Keywords: Action; Triads; Categorisation; Priming

Introduction

Research into conceptual knowledge demonstrates that knowledge of action influences categorisation judgments (Borghi, Flumini, Natraj & Wheaton, 2012; Chao & Martin, 2000; Iachini, Borghi & Senese, 2008; Kalénine, Shapiro, Flumini, Borghi & Buxbaum, 2013; Shipp, Vallée-Tourangeau, & Anthony, 2014). For example Iachini et al. (2008) showed that when participants categorised cups varying in size, shape and grip method, they used the grip of the object as the primary strategy for categorisation. What is evident in such research is that the influence of action becomes particularly salient when participants are required to physically make the action associated with an object. For example participants in Bub, Masson and Cree (2008) performed a variant of the Stroop (1935) task where gestures were associated with colours. Objects were shown on a screen in varying colours and participants were instructed to make the gesture that they had previously associated with that colour. Participants were faster when the gesture they performed was congruent with the action that would normally be used to operate the object seen. Reaction times significantly increased when the action performed was incongruent with that normally associated with the object.

Shipp et al. (2014) found that action was not a primary source of categorising in a forced-choice triad task, but that it did have an additive effect. Participants were shown triads where a target was matched with a choice item sharing a taxonomic relation but no action, and a choice item sharing an action but no taxonomic relation. For example the target of *calculator* was presented with *set square* (taxonomically related, *stationary*) and *mobile phone* (action related, both operated by pressing buttons). In these Different Category Object (DCO) triads (see Fig. 1), participants were most likely to select the taxonomic choice when the objects were shown on a white background as *context-lean.* However in the *context-rich* condition where the objects were shown being used in a functional manner by an agent, participants were more likely to select the action-related item compared to the context-lean condition. Participants were also shown Same Category Object (SCO) triads where participants matched a target with one of two choice options which both shared a taxonomic relation to the target, but one also shared an action. For example *orange* was shown with *strawberry* (taxonomic, non-action) and *banana* (taxonomic/action, both require a peeling action). In both the context-lean and context-rich conditions participants were more likely to select the item sharing both a taxonomic and an action relation to the target. In order to rule out the possibility of perceptual features confounding the explanation (it is possible that participants chose *mobile phone* to go with *calculator* because they look similar) a series of Perceptual Object Category (PCO) triads were designed. In these PCO triads the target was presented with a choice sharing perceptual features but not taxonomic and not action relation, and a choice sharing an action but not perceptual or taxonomic relation. For example the target of *cocktail shaker* was presented with *vase* (perceptual choice) and *maracas* (action choice). The results showed that participants were significantly more likely to select the action choice when

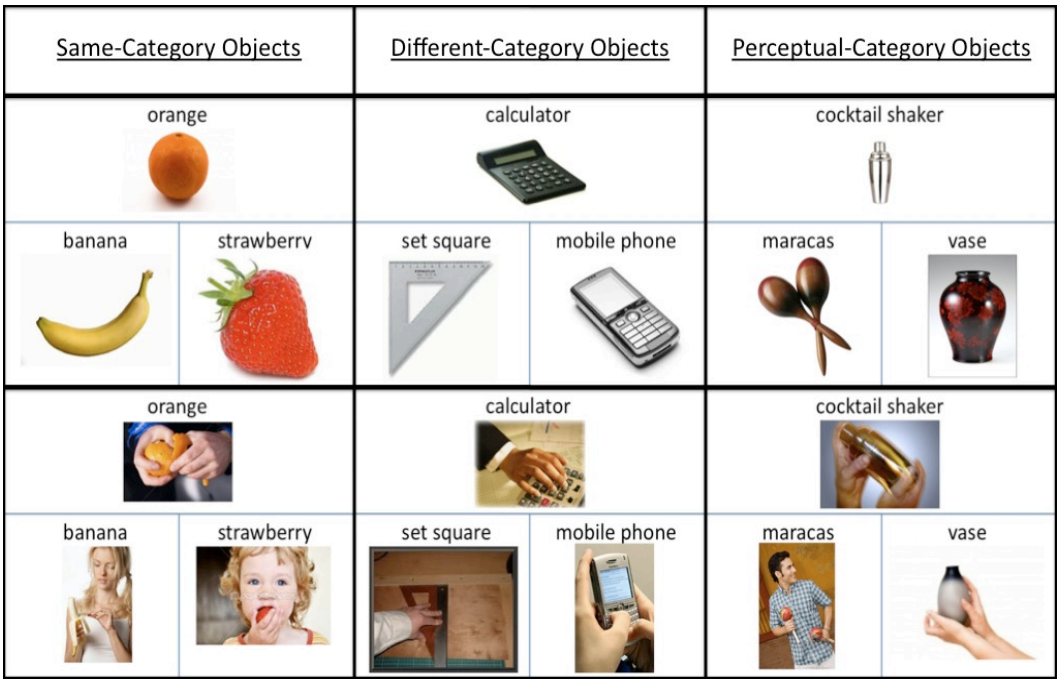

Figure 1. Examples of stimuli employed in the experiment. From left to right: Same Category Object triad, Different Category Object triad, and Perceptual Category Object triad in the context-lean condition (top panels) and in the context-rich condition (bottom panels).

Figure 2. Arrangement of the objects shown to participants in the Action Priming condition including additional resources as necessary.

shown in the context-rich condition supporting the notion that context enhances action choices. It further pre-empts the potential criticism that the action choices were being selected because of their perceptual similarities. Shipp et al. demonstrated that action is not used in categorisation when it stands alone but has an additive effect when matched with taxonomic relations, and its effect is heightened when shown in context.

The aim of the current research was to examine how participants perform on the forced-choice triad task used in Shipp et al. (2014) after they were primed with the physical actions that relate to the triad items. In addition research supports that differences exist between performing physical actions on objects compared to the intention to act (Jax & Buxbaum, 2010; Osiurak, Roche, Ramone & Chainay, 2013). Jax and Buxbaum showed

that when participants were instructed to put their hand on an object as though they would either use it or pass it to the experimenter, they were faster on the latter. Osiurak et al. not only replicated the results of Jax and Buxbaum, but also showed the reverse when participants were asked to actually pick up and use the object or pick it up and pass it to the experimenter. Borghi, Bonfiglioli, Lugli, Ricciardelli, Rubichi and Nicoletti (2007) showed primes of either a precision or a power grasp to participants followed by an object that would either be picked up with a precision or a power grasp. Previous research would suggest a strong compatibility effect (Ellis & Tucker, 2000; Tucker & Ellis, 1998, 2001) when asked to categorise the object as either natural or man-made, but this pattern was only found when participants had completed a motor training phase prior to this task.

The present experiment had two main aims. First to replicate the findings of Shipp et al. (2014) with action based choices being selected with higher frequency when shown in context, and when it also shared a taxonomic relation to the target. The second aim was to see if these action choices were more frequent when participants had previously interacted with the objects in a functional capacity. All of the items used were presented to participants prior to the triad task and participants completed either an action (using the objects), taxonomic (grouping the objects) or a movement (picking up the objects) priming phase. It was predicted that the action priming phase should lead to higher action choices on the triad task than the taxonomic or movement priming.

Method

Participants

Fifty-six undergraduate Psychology students (9 males, 47 females, M_{age} = 22.87, SD = 6.34) from the University of Hertfordshire took part in the experiment in return for course credit.

Materials

The triads used in Shipp et al. (2014) were considered for the present experiment consisting of ten of each triad type (see Fig. 1). It was important that all of the items in the triads could be interacted with prior to the triad task in the priming phase. Physical constraints of the items (e.g., *fax machine, bed, piano)* or to ethical considerations (*rifle, saw, axe*) meant that not all the original triads could be used. The final set of 16 triads consisted of five SCO triads (*pencil, glass, pin, orange,* leaflet), six DCO triads (*screwdriver, drink bottle, mug, calculator, book, paperclip, deodorant*) and five PCO triads (*USB pen, present, calculator, peppermill, handbag*). In the same manner as Shipp et al. context was manipulated: In the context-free condition the triads were presented as isolated items on a white background. In the context-rich condition participants saw the objects being used by an agent in a functional scene. All the 48 items that comprised the triads were then physically collected for use in the priming phase. The Action priming task was designed so that participants were presented with a list of tasks that involved using each item in its functional capacity such as writing their name with a pencil or reading a passage from a book.

Procedure

All participants upon entering the room saw the 48 items used in the triads presented on a table (see Fig. 2) and initially completed the priming phase. Participants were assigned to one of three priming task; action, taxonomic or movement priming. Those in the action priming completed a checklist task where the experimenter read out each task one-by-one which the participant had to complete before moving on to the next task. Each task involved using the object in its functional capacity and could either be completed on its own (e.g., *"tie the shoelace on the shoe", "open the book on any page and read out the top line"*) or were presented with additional resources (e.g., *"write your name on a piece of paper"* – where paper was provided to the participant though not included in any of the triads). Participants were instructed to move at their own pace and that there was no time limit to this task. Participants in the taxonomic priming were asked directly to sort the items into categories. They were told that they could sort them however they liked providing that each resulting group had a minimum of two members and that they would have to explain their groupings afterwards. They were also told that each sort must have a valid reason behind it and no items should be grouped together based on being remaining items that did not fit into other categories. Afterwards participants were asked to explain their decisions and describe what each category comprised. Again, no time limit was placed on the task and participants performed at their own pace. Participants in the movement priming saw two tables, one of which had all the 48 items on it, and were simply asked to pick up each item and move it to the next table in their own time. This was in order that the participants interacted with the object but not with respect to its intended function. Again no time limit was placed onto the task and participants performed at their own pace. After the priming phase concluded participants in each priming condition were allocated to either the context-lean or context-rich condition to undertake the triad task. This was completed immediately after the priming task took place with approximately two minutes between completion of the priming task and onset of the triad task. Thus the experiment employed a mixed design with three factors, Priming (action, taxonomic, movement), Triad Type (SCO, DCO, PCO), and Context (lean, rich), with triads as a repeated measures and priming and context as between subjects factors.

The triad task was presented Using Superlab on a 15" Macintosh laptop and began with a practice trial to show the participants the format of the triads on screen. Each trial began with a fixation cue presented at the top of the screen for 1000ms after which the cue disappeared and the target appeared consisting of the word and the appropriate picture depending on the experimental condition (context-lean or context-rich). After 1500ms the two choice options appeared beneath the target alongside the appropriate images. Using the same instructions as in Shipp et al. (2014) participants were instructed to "select the choice item that goes best with the target". Participants were

Table 1. *Mean percentage of action choices in the DCO, SCO and PCO triads across context and priming.*

Triad	Priming	Context	
		Lean	Rich
DCO	Action	.53	.58
	Taxonomic	.32*	.35
	Movement	.46	.40
SCO	Action	.48	.66*
	Taxonomic	.60	.54
	Movement	.48	.48
PCO	Action	.48	.78*
	Taxonomic	.50	.58
	Movement	.40	.65

Note. *Indicates those mean scores that significantly differed from a 50/50 chance ratio.

instructed to press the 'a' key to choose the item on the left-hand side of the screen and the 'l' key for the item on the right-hand side of the screen. The choice items were counterbalanced across the triads so that in half the triads the action choice appeared on the left hand side while in the remaining half the action choice appeared on the right. After they had made their choice the triad disappeared and the fixation cue appeared again for the next triad. Participants completed all 16 trials and were debriefed.

Results

The mean proportion of action responses was calculated for the SCO, DCO and PCO triads across context and priming. As was found in Shipp et al. (2014) participants showed a tendency to select the action choice more with the SCO (54%) and PCO (57%) triads than with the DCO triads (44%), and more so in the context-rich (58%) than in the context-lean (47%) condition. In addition Figure 3 shows that action choices were higher following the action priming (59%) than in the taxonomic (48%) and movement (48%) priming. A 3x2x3 mixed Analysis of Variance was used to analyze the mean action responses using Triads as a within subjects factor and Priming and Context as between subjects factors. The analysis revealed a significant main effect of Context with a higher number of action choices in the context-rich condition, $F(1, 50) = 5.25$, $p = .026$, $\eta^2 = .1$. The main effect of Triads was significant, $F(1.84, 92.67) = 6.74$, $p = .002$, $\eta^2 = .12$. Post hoc analysis using the Bonferroni adjustment found that the action responses on the DCO triads were significantly lower than both the SCO triads ($p = .046$) and the PCO triads ($p = .004$). No difference was found between the SCO triads and the PCO triads ($p = 1.$). The main effect of Priming was also found to be significant, $F(2, 50) = 3.84$, $p = .028$, $\eta^2 = .13$. Post hoc analysis using the Bonferroni adjustment revealed that the difference between action and taxonomic priming ($p = .063$) and the action and movement priming ($p = .066$) were marginally significant (see Fig. 3). The difference between the taxonomic and moving priming was not significantly different ($p = 1.$).

The two-way interaction effect between Context and Triads was significant, $F(1.84, 92.67) = 4.58$, $p = .012$, $\eta^2 = .08$. Post hoc analysis using the Bonferroni adjustment (see Fig. 4) found no effect of context on the DCO ($p = .92$) and SCO triads ($p = .45$), but action choices were significantly higher for the PCO triads in the context-rich than context-lean condition ($p < .001$). The two-way interaction between Priming and Triads was not found to be significant, $F(3.71, 92.67) = 2.02$, $p = .10$, $\eta^2 = .08$, nor was the two-way interaction between Priming and Context, $F(2, 50) = 1.72$, $p = .19$, $\eta^2 = .06$, or the three-way interaction between Context, Priming and Triads, $F < 1$.

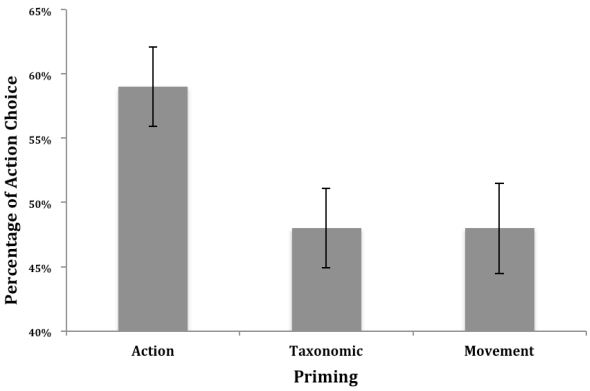

Figure 3. Mean percentage of action choices across the Action, Taxonomic and Movement Priming conditions. Error bars are standard errors of the mean.

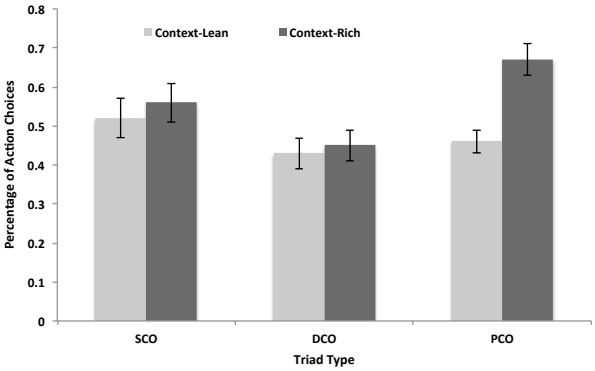

Figure 4. Mean percentage of action choices with Same Category Object (SCO), Different Category Object (DCO), and Perceptual Category Object (PCO) triads in the context-lean condition (light grey bars) and in the context-rich condition (dark grey bars). Error bars are standard errors of the mean.

Due to the dichotomous nature of the response variable it is possible that the mean action scores were no different

from selecting the action choice by chance. Therefore further post hoc analyses were conducted on the mean percentage of action choices across the conditions in order to assess if the means were significantly different from a 50/50 ratio. Single sample t-tests were conducted on the cell means shown in Table 1 using a theoretical mean of 0.5. Only the SCO and PCO triads following the action priming were significantly higher than chance ($p < .05$). The DCO mean following the action priming was higher than chance but not significantly so ($p = .21$). This partially supports the previous ANOVA analysis where higher action choices followed only the action priming. However this effect was not consistent for all the triad types. In addition the only action scores that were significantly lower than chance was on the DCO triads following the categorisation priming ($p = .03$).

Discussion

The results of the current experiment revealed three main findings. The first is the replication of the triad effect from Shipp et al. (2014). The action choice was least likely to be selected on the DCO triads when choosing between a taxonomic and an action choice. This shows that, as with the previous experiments, action information alone is less likely to be favoured as the basis for category membership when the alternative is taxonomic information. The action item was most likely to be selected with the SCO and the PCO triads. The results on the SCO triads support the notion of action having an 'additive' effect making such items sharing both action and a taxonomic relation as 'better' category members. The PCO triads further show that when no taxonomic relation is present as an alternative participants are more likely to use action than perceptual properties to group items together.

The second main finding is the partial replication of the context effect from Shipp et al. (2014). While previously it was found that across all three triads the action choice was most likely selected in the context-rich condition, this effect was limited with the PCO triads in this experiment. The most likely reason for this is the exclusion of certain triads from the original set used in Shipp et al. It is possible that these triads removed were more likely to lead to the action choice than other triads. An item analysis of the triads used in Shipp et al. (2014) supports this showing that certain items are more susceptible to context effects than others (Shipp, Vallée-Tourangeau, & Anthony, in prep). For example the *rifle/sword/water pistol* triad (DCO) was removed from the present experiment for practical reasons but has been shown to be strongly influenced by context.

The third main finding from this experiment is the effect of priming conditions. The results showed that participants were more likely to choose the action related item in the triads following the action priming where all the items were used in their functional capacity. The selection of action choices in the SCO and PCO triads were significantly higher than chance in the context-rich condition following the action priming. Selection of the action choice in the DCO triads was not significantly higher than chance. Such results are in line with notions of situated simulation (Barsalou, 1999; 2003; 2008; Yeh & Barsalou, 2006). Barsalou (2003) states that category features recently encountered become more readily available for subsequent processing. If someone recently peeled an orange then *peeling* should be temporarily more salient than other, more context-dependent, properties. Therefore prior functional engagement with the objects in the initial task could temporarily increase the saliency of the shared actions and have a direct influence on the simulations made, and hence on the choices in the triad task. Variations in how the participants interact with the objects would be expected to influence the simulations generated. Therefore participants who interacted with the items functionally should be more likely to simulate those recent actions and the salience of these could be further enhanced by the context shown. As such a transfer effect occurs in which the interaction with the objects directly facilitates the simulations generated. As the taxonomic and movement priming does not focus on the shared actions participants would be less likely to simulate the relevant actions associated with use and so less likely to select the action choice in the triads (as was found in the data).

An alternative explanation might be linked to functional actions, in comparison to structural actions, resulting in longer lasting neural representations (Bub & Masson, 2012; Jax & Buxbaum, 2010). The priming tasks used here can be separated into two distinctive sets of actions, functional actions related to functional use and volumetric/structural actions related to general movement and interacting with the objects in a non-functional manner (Bub & Masson, 2012; Bub et al., 2008; Jax & Buxbaum, 2010; Osiurak et al., 2013). Buxbaum and Kalénine's (2010) Two Action Systems (2AS) model proposes that the brain has separate action systems for the processing of functional and structural actions. The dorso-dorsal stream is specialized for acquiring information based on the structure of objects and their affordances whereas the ventro-dorsal system is specialized for the retrieval of conceptual representations. Functional activations tend to be long lasting and can cause interference effects on later actions (Bub & Masson, 2012; Jax & Buxbaum, 2010). Structural activations occur more quickly than functional, but decay rapidly and do not cause later interference effects. Jax and Buxbaum showed that when participants performed a functional action on an object and then later performed a grasp action, response latencies were significantly longer than when they performed the grasp action first. This interference effect as a result of functional activation lasted for approximately 20 minutes during the entire task. While this functional activation had an interference effect on the use/grasp task, it is possible that this has a facilitation effect on the triad task. The partial re-activation of the neurons during simulation of the objects in the triad should be facilitated by the current activation of the functional system. As such the simulation itself should make the action element more salient between the triad objects and participants will therefore be more likely to select the action choice. This is further amplified by the concurrent activation of conceptual knowledge with the functional system of the ventro-dorsal stream as proposed by Buxbaum and Kalénine (2010). The same facilitation

effect does not occur following the movement prime as the structural activations of the dorso-dorsal stream dissipate quickly. Hence only the long lasting functional activations as a result of the action priming should lead to higher action choices in the triad task. However it should be noted that such an explanation is purely speculative at this point as the data cannot be used to explicitly support such claims. However the ventro-dorsal facilitation effect could be tested and supported through using the full set of triads developed from Shipp et al. (2014). As explained above the full range of triads was not used in this experiment because of ethics and feasibility of priming how participants use certain objects such as *sword*. If it is the case that functional activations of the ventro-dorsal system facilitate simulations of the objects, then in the triad task used here this should result in higher action choices on the primed objects and lower action choices for those objects not primed. Future research should aim to compare performance on such triads in this task.

In conclusion the data reported here has shown that the triad effect found in Shipp et al. (2014) has been replicated. Participants were more likely to use action as a source for categorisation on the forced-choice triad task when it was shown in combination with taxonomic information, and when it was shown in context. The results further show that priming participants with the functional rather than structural actions of the objects led to increased action choices on the triad task. Such results are also in line with the view that a transfer effect occurs from the object-interaction task which facilitates how objects are mentally simulated (Barsalou, 1999, 2003; Yeh & Barsalou, 2006).

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