Yin, J. and Csibra, Gergely and Tatone, D. (2022) Structural asymmetries in the representation of giving and taking events. Cognition 229 , p. 105248. ISSN 0010-0277.

Cognition 229 (2022) 105248

Contents lists available at ScienceDirect

Cognition

journal homepage: www.elsevier.com/locate/cognit

Structural asymmetries in the representation of giving and taking events

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ARTICLE INFO

Keywords:
Giving
Taking
Change detection
Binding
Event representation

ABSTRACT

Across languages, GIVE and TAKE verbs have different syntactic requirements: GIVE mandates a patient argument to be made explicit in the clause structure, whereas TAKE does not. Experimental evidence suggests that this asymmetry is rooted in prelinguistic assumptions about the minimal number of event participants that each action entails. The present study provides corroborating evidence for this proposal by investigating whether the observation of giving and taking actions modulates the inclusion of patients in the represented event. Participants were shown events featuring an agent (A) transferring an object to, or collecting it from, an animate target (B) or an inanimate target (a rock), and their sensitivity to changes in pair composition (AB vs. AC) and action role (AB vs. BA) was measured. Change sensitivity was affected by the type of target approached when the agent transferred the object (Experiment 1), but not when she collected it (Experiment 2), or when an outside force carried out the transfer (Experiment 3). Although these object-displacing actions could be equally interpreted as interactive (i.e., directed towards B), this construal was adopted only when B could be perceived as putative patient of a giving action. This evidence buttresses the proposal that structural asymmetries in giving and taking, as reflected in their syntactic requirements, may originate from prelinguistic assumptions about the minimal event participants required for each action to be teleologically well-formed.

1. Introduction

The active transfer of resources (i.e., giving valuable goods to others) represents one of the most widespread types of altruistic behaviors in our species (Gurven & Jaeggi, 2015; Gurven, Stieglitz, Hooper, Gomes, & Kaplan, 2012). A conspicuously rare phenomenon in non-human primates (Feistner & McGrew, 1989), giving has been documented across all known societies in a suite of relational contexts: from family provisioning to reciprocal exchange, through courtship gifting, and so on (Jaeggi & Gurven, 2013; Widlok, 2016). The cross-cultural ubiquity of giving and its functionally manifold role in structuring key social relations recently led to the proposal that humans evolved a dedicated mechanism – a giving action schema (Frankenhuis & Barrett, 2013; Tatone, Geraci, & Csibra, 2015) – for monitoring and navigating interactions based on active resource transfer.

Supporting this idea, developmental studies documented an early preparedness to interpret giving actions (Gordon, 2003; Schöppner, Sodian, & Pauen, 2006; Tatone et al., 2015; Thoermer, Neumann, & Sodian, 2012). Three notable findings emerged from this literature. First, minimal cues of possession transfer suffice to induce the representation of giving. For instance, infants exposed to an agent pushing an object next to a motionless patient interpreted this action as directed to the patient despite the absence of any reaction on their part (Tatone et al., 2015; Tatone & Csibra, 2020; see also: Geraci & Surian, 2011; Meristo, Strid, & Surian, 2015). Strikingly, infants adopted a similar event interpretation even when the displacement of the object next to the patient could be disregarded as side effect of the agent's pursuit of a different goal (Tatone, Hernik & Csibra, 2021). These findings suggest that infants are compelled to represent an agent adjacent to the endpoint of a displaced object as its putative recipient. Second, giving is primarily interpreted as an interaction between two agents rather than as the expression of an individual disposition. Infants who observed an agent giving to a certain recipient did not expect the agent to later transfer the object to novel recipients, suggesting that they represented the action as specific to the observed pair (Tatone et al., 2015; Tatone & Csibra, 2020). Third, infants do not interpret other object-displacing actions as patient-directed, despite their surface similarity to giving. While giving an object to a passive patient is sufficient to motivate its inclusion in the

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https://doi.org/10.1016/j.cognition.2022.105248
Received 11 February 2022; Received in revised form 28 July 2022; Accepted 1 August 2022

represented event, this is not the case when the patient has her possession taken away (Tatone et al., 2015).

1.1. Interpretive asymmetries within and before language

The infants' propensity to include patients in the representation of giving, but not taking, events dovetails cross-linguistically robust differences in the syntactic requirements of GIVE and TAKE verbs: GIVE requires the patient argument to be made syntactically explicit (unless implied in the sentence structure), whereas TAKE does not (Kittila, 2006). This difference is thought to reflect how semantic roles are distributed in the two events (Newman, 1996, 2005). In GIVE the agent and the beneficiary of the action refer to distinct participants, and thus require distinct grammatical arguments, whereas in TAKE these roles are borne out by one participant: the Taker, who is at once the agent causing the transfer and experiencing its effects.

The developmental studies mentioned above suggest that this difference in syntactic requirements may be rooted in prelinguistic assumptions about the minimal number of participants that giving and taking actions respectively entail. Giving requires a patient to be specified, insofar as its goal can be meaningfully understood only in relation to its social effects (i.e., bestowing someone with a resource). Taking, on the other hand, can be meaningfully apprehended as directed to the goal of object acquisition even if these social effects (i.e., depriving someone of her possession) are not factored in, thus making the inclusion of the patient facultative.

The idea that differences in syntactic elaboration may reflect the extent to which event participants are entailed by prelinguistic action concepts suggests that structural asymmetries in event representation should also be found in adults in absence of explicit linguistic mediation. A recent EEG study corroborates this suggestion (Yin, Tatone, & Csibra, 2020). Adult participants produced a stronger alpha-band suppression (an electrophysiological correlate of action understanding sensitive to the perceived interactivity of actions: Yin, Ding, Xu, Zhang, & Shen, 2017) when presented with an agent transferring an object to an animate target (as in giving) over an inanimate one, whereas no such difference emerged when the agent collected the object from an animate target (as in taking) over an inanimate one. That is, adults spontaneously distinguished giving from kinematically identical acts of nonsocial object displacement but did not distinguish taking from instances of nonsocial object acquisition. These findings suggest that adults, like infants, interpreted giving and taking in structurally different ways: the former as a dyadic interaction ('A gives X to B'), and the latter as an object-directed action ('A takes X').

1.2. The present study

Building on Yin et al. (2020), in the present study we sought to provide additional supporting evidence for the aforementioned asymmetry using a change-detection task. This allowed us not only to complement the findings of Yin and colleagues with behavioral data, but also to investigate whether, beyond online event processing, this difference in event construal would similarly influence information encoding in working memory (WM). A burgeoning literature demonstrates that the perception of social interactions provides a principle for chunking information in WM. For instance, the binding of two agents in an interactive unit has been shown to lead to increased recognition accuracy (Bellot, Abassi, & Papeo, 2021; Paparella & Papeo, 2022), improved retention of the actions of individual agents (Ding, Gao, & Shen, 2017), and better feature retrieval (Vestner, Tipper, Hartley, Over, & Rueschemeyer, 2019). Together, these studies suggest that visuospatial cues of potential interactions, such as proximity and facingness, offer a structure for organizing the representation of its participants in WM. Capitalizing on this literature, we hypothesized that giving, owing to its mandatory three-place structure, should spontaneously induce adults to bind agent and patient in an interactive unit, whereas taking, owing to its two-place structure, should not. Following previous studies (e.g., Ding et al., 2017; Yin, Chen, Wang, & Ding, 2018), we assessed binding by measuring the participants' sensitivity to change.

We tested this hypothesis across three experiments with the same design structure. In each experiment, we compared the participants' sensitivity to change for transferring actions that could be interpreted as interactive (because directed to an agent) relative to actions that could not (because directed to an inanimate object). Thus, rather than directly contrasting giving with taking, for each participant we assessed how they represented these events relative to their nonsocial counterpart. Doing so allowed us to minimize perceptual confounds (insofar as giving and taking differ in their physical configuration) as well as the possibility of carry-over effects (cf. Yin et al., 2020).

Each experimental trial was composed of two phases: a *memory phase* and a *test phase*. During the memory phase participants were presented with a series of animations (memory events), each involving an active agent pushing an object towards or away from one of two possible targets: a passive agent (animate target) or a rock (inanimate target). Afterwards, participants were presented with a test event which featured (1) one of the memory events (e.g., AB), (2) an event with a novel agent combination (e.g., AC), or (3) a memory event with the agents' roles reversed (e.g., BA). Participants were tasked with answering whether they detected any change at test.

In Experiment 1, we tested how adults encoded events featuring *transferring* events (i.e., pushing an object towards a target) directed to animate or inanimate targets. We expected participants to bind active and passive agent together only when the latter was the target of the agent's action – only when it could be represented as a putative recipient of the transferred object rather than a mere bystander. If so, we should observe the participants' change sensitivity to be modulated by target (animate vs. inanimate). In Experiment 2, we tested how participants encoded events featuring *collecting* actions (i.e., pushing an object away from a target). This experiment allowed us to assess whether taking actions, which can be similarly construed in interactive terms, would also induce agent-patient binding. Based on the findings of Yin et al. (2020), which suggested that adults, like preverbal infants (Tatone et al., 2015), prioritized an object-directed interpretation of taking, we predicted that the role that the passive agent played in the event (patient vs. bystander) should not matter for its encoding. If so, we expected change sensitivity to not be modulated by target type. Finally, in Experiment 3 we tested how participants encoded events featuring *transferring* actions caused by an outside force (i.e., a mechanical hand), without any involvement from either agent. This experiment was intended to rule out the possibility that binding of agent and patient might have been due to their attentional highlighting via the object's motion, irrespective of any concurrent social interaction.

2. Experiment 1: Giving vs. disposing

In Experiment 1 we tested whether giving induced the binding of an active and passive agent into an interactive unit. To this end, we presented participants with two types of kinematically identical transfer events differing only with respect to which of two targets was approached by the agent pushing the object: a passive patient (*giving*) or an inanimate object (*disposing*). We reasoned that participants should be more likely to bind the active and passive agent when these could be assigned thematically meaningful roles within a structured representation. This should be the case when the passive agent can be interpreted as a putative recipient of the transferred object (in giving) rather than as a mere bystander of its displacement (in disposing). To test this, we assessed the participants' sensitivity to two types of changes: pair change (e.g., AB becomes AD) and role change (e.g., AB becomes BA).

We hypothesized that selective binding of the two agents in the giving case should be reflected in event-specific differences in change sensitivity. Specifically, we predicted that binding should be reflected in (1) a higher sensitivity to pair changes and (2) a lower sensitivity to role changes for giving relatively to disposing. The first prediction follows from previous work (e.g., Ding et al., 2017; Vestner et al., 2019) showing that binding promotes the encoding of agent-specific features. Based on these findings, we expected participants to be better able to encode the identity of the agents in the giving event, and consequently more likely to detect changes in pair composition. The second prediction rests on the first: detecting a role change should be easier for displacing events, because these, unlike giving, should induce the encoding of only one agent (i.e., the agent pushing the object). For such events, role reversal corresponds to a peripherally encoded agent (B) replacing a centrally encoded agent (A). Detecting a change in this case thus would simply amount to noticing that the identity of the centrally encoded agent has changed (e.g. 'did I see A?'). This strategy is not available for giving, which, by hypothesis, is expected to prompt the integration of both active and passive agent in the event representation. In this case, detecting a change requires participants to genuinely compared an agent's previously occupied role within the interaction with the one presented at test (e.g., 'did I see A giving to B?'). Given the more cognitively demanding nature of this verification strategy, we expected participants to produce more errors (and thus show a lower role-change sensitivity) in giving compared to disposing.

2.1. Methods

2.1.1. Participants

Twenty-four paid adult volunteers (11 males and 13 females; mean age = 21 years; age range = 18–25 years) participated in this experiment. To determine sample size, we conducted a power analysis using G*Power 3.0 (Faul, Erdfelder, Buchner, & Lang, 2009), with a conservative medium effect size ($d = 0.60$), an alpha level of 0.05, and a power of 0.80. The effect size estimate was taken from a recent study (Yin et al., 2020) which used the same stimuli and the same within-group comparison as our current work. The sample size suggested by the power analysis was 24, which matches that of previous literature investigating how adults encode social interactions and action roles (e.g., Ding et al., 2017; Hafri, Trueswell, & Strickland, 2018; Sedikides, Olsen, & Reis, 1993).

All participants were briefed about the purpose and the procedural details of the experiment and signed an informed consent form prior to testing. The study was approved by the Research Ethics Board of the Department of Psychology at Ningbo University and conducted in full accordance with the relevant university guidelines and regulations. In all of the experiments, we report all measures, manipulations, and exclusions. All data and supplementary videos are publicly available via the Open Science Framework, and can be accessed at: https://osf.io/zwgrd/?view_only=0f91e593d6ce4d09a438fe8eac57ff6f.

2.1.2. Apparatus and stimuli

The stimuli were presented on a 19-in. CRT monitor (resolution = 800 × 600 pixels; refresh rate = 100 Hz) placed at a 100 cm viewing distance from the participant. The stimulus presentation was controlled through a custom-built MATLAB script, using the Psychophysics

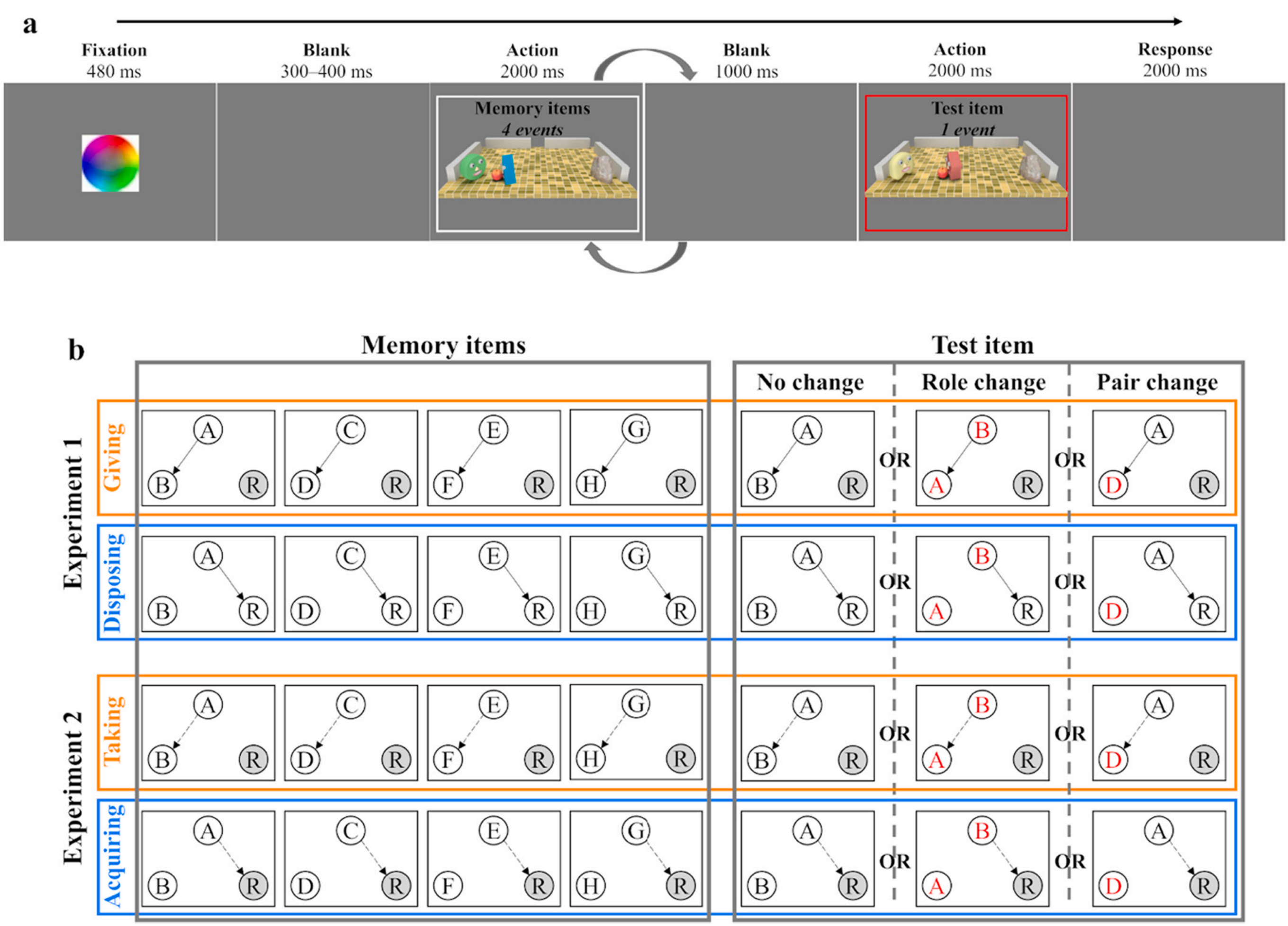

Fig. 1. Overview of the experimental procedure and conditions. (a) Illustration of the experimental procedure for a single trial. (b) Operationalization of conditions. The letters "A" to "H" represent different agents, and the letter "R" represents the rock. The test items are illustrative examples, as they were selected randomly from the memory items.

Toolbox (Brainard, 1997). The stimuli consisted of animations depicting transfer events and were made in Blender (version 2.80). These events were displayed at the center of the screen at 11.1° × 8.3° viewing angle. Each event (2 s of total running time) included two featurally different animate characters (an active agent, hereafter 'agent', and a motionless agent, hereafter 'passive agent'), a rock, and an apple. For each event, a pair of two characters was randomly selected from a set of 10 predefined geometrical shapes, each rendered with a distinctive shape and color (see the Supplementary Materials for details of randomization). All the events shared the same layout and spatial arrangement: the agent was positioned 1.6° right above the center of the stage (subtending 11.1° × 7.1°), while the passive agent and the rock were positioned on the left or right lower side of the stage, respectively (see Fig. 1a). The location of the passive agent and the rock was counterbalanced across trials for each participant.

There were two types of events: *giving*, in which the agent pushed the apple next to the passive agent, and *disposing*, in which the agent pushed the apple next to the rock (Fig. 1). In the giving event, the agent pushed the apple from the upper to the lower side of the stage for about 2.8° (0.5 s), turned left or right towards the passive agent (0.1 s), continued moving towards the patient, released the apple in front of it (0.5 s), and then returned to its initial position (0.9 s). The action in the disposing event was kinematically identical to the action used in the giving event.

2.1.3. Procedure and design

In each trial (see Fig. 1a), a dynamic fixation stimulus was presented at the center of the screen for 480 ms, followed by a blank background (300 ms to 400 ms). Afterwards, four transfer events (memory events) were sequentially shown within a white frame. Each event was followed by a blank background (1000 ms). Following this phase, an additional transfer event was presented within a red frame, which indicated to the participants that this was a test event. At the end of test event, participants were required to judge whether this test event matched one of the memory event. The participants were instructed to press the "J" key on the keyboard to indicate 'yes' (no change) or the "F" key to indicate 'no' (change). The participants were not told in advance what types of changes might occur. After the key press, an intertrial interval of 1500 ms followed. If no response occurred within 2000 ms, the task automatically proceeded to the next trial.

Within each trial, memory and test events featured the same type of action (i.e., only giving or only disposing). Each memory event featured a new pair of agents with distinct appearances. Which of the four memory events was selected for creating the corresponding test event within a trial was randomly determined. There were three types of test events: (1) no change (the event was identical to one of the memory events); (2) role change (two agents from the selected memory event swapped roles); (3) pair change (the active agent from the selected memory event was paired with a passive agent from another memory event).

To meet requirements for computing sensitivity to change and to counterbalance the trials across test events, the number of no-change trials was twice of the number of change trials. Half of the no-change trials was notionally assigned to the role change condition, and the other half to the pair change condition. These trials did not differ in any sense; they were just differentiated to equalize trials across conditions. As a result, 8 conditions were generated by crossing the type of event (giving vs. disposing), the required response (change vs. no change), and the type of change (role change vs. pair change). Each condition included 20 trials, resulting in a total of 160 trials. The trials were divided into 4 blocks, each followed by a 5-min break, and were presented in pseudorandom order (the same condition could not be repeated for more than three consecutive trials).

To examine whether the type of event (giving vs. disposing) and the type of change (role change vs. pair change) affected the ability to detect changes, the accuracy of responses was assessed by calculating the sensitivity (d') of participants to change, compared to no change (for additional details, including descriptive results and analyses of the decision criterion, see the Supplementary Materials). To avoid infinite hit rate or false alarm rate when computing d', 0.5 was added to each frequency (see Snodgrass & Corwin, 1988), and the result was divided by $N + 1$, where N is the number of trials in that condition.

In terms of this dependent variable, the experimental design could be thus simplified as a 2 (event type: giving vs. disposing) by 2 (change type: role change vs. pair change) within-subject factorial design. Two-way analyses of variance (ANOVAs) were conducted on the d' data. Besides traditional null hypothesis testing, we also calculated Bayes factors (BF_{10}, H1/H0 as computed here) as the ratio of the likelihood of two competing hypotheses using jamovi (jamovi project, 2021). We considered Bayes factors below 0.33 as substantial evidence against between-condition differences, and Bayes factors above 3.00 as substantial evidence supporting between-condition differences (Dienes, 2014).

2.2. Results & discussion

An ANOVA on the d' values (Fig. 2a) revealed no main effects (event type: $F(1,23) = 0.40$, $p = .399$, $\eta_p^2 = 0.03$, $BF_{10} = 0.26$; change type: $F(1, 23) = 2.94$, $p = .100$, $\eta_p^2 = 0.11$, $BF_{10} = 1.05$) but a significant interaction between event and change type ($F(1, 23) = 14.38$, $p = .001$, $\eta_p^2 = 0.39$, $BF_{10} = 43.38$). To explore the interaction, we performed simple-effect tests for each change type, and found that the participants were more sensitive to role change than pair change in disposing events ($t(23) = 3.63$, $p = .001$, Cohen's $d = 0.74$, $BF_{10} = 26.21$, 95% of mean difference = [0.24, 0.88]), but not in giving events ($t(23) = 0.99$, $p = .332$, Cohen's $d = 0.20$, $BF_{10} = 0.33$, 95% CI of mean difference = [−0.46, 0.16]). Importantly, when comparing change types, these tests revealed higher sensitivity to role change in disposing ($M = 1.88$; $SD = 0.71$) than giving events ($M = 1.60$; $SD = 0.62$; $t(23) = 2.71$, $p = .013$, Cohen's $d = 0.55$, $BF_{10} = 3.99$, 95% CI of mean difference = [0.07, 0.50]) and higher sensitivity for pair change when exposed to giving ($M = 1.75$; $SD = 0.75$) compared to disposing events ($M = 1.32$; $SD = 0.74$; $t(23) = 3.01$, $p = .006$, Cohen's $d = 0.61$, $BF_{10} = 7.18$, 95% CI of mean difference = [0.13, 0.72]).

These results suggest that giving led participants to bind agent and passive agent together, as attested by the modulation of change sensitivity by event type, in two ways: (1) a higher sensitivity to pair change for giving over disposing (reflecting a more robust encoding of the identities of interactively related agents), and (2) a complementarily lower sensitivity to role change for giving over disposing (reflecting a weaker encoding of the agents' respective positioning within the pair). These results are compatible with the hypothesis that participants grouped the two agents in virtue of their participation in a giving-based interaction. However, it may also be possible that such binding was induced by mere cues of social approach (i.e., A moving towards B), independent of the transfer concomitantly taking place, or by the perception of any transfer-mediated interaction. If so, other types of transfer, such as taking, may be equally suited to induce binding. Experiment 2 was designed to examine these possibilities.

3. Experiment 2: Taking vs. acquiring

In Experiment 2 we tested whether the pattern of change sensitivity documented in the previous experiment, which we argued to constitute evidence of agent-patient binding, could be similarly induced by the observation of taking actions. Owing to its surface similarities with giving (both actions can be represented in a three-place structure), taking is well suited for testing the specificity of the factors responsible for such binding. If the integration of the two agents within an interactive unit observed in Experiment 1 was prompted by generic cues of social approach (preserved in taking) or other actions causing possession transfer (of which taking is an instance), then the same pattern of change sensitivity as in the previous experiment should obtain.

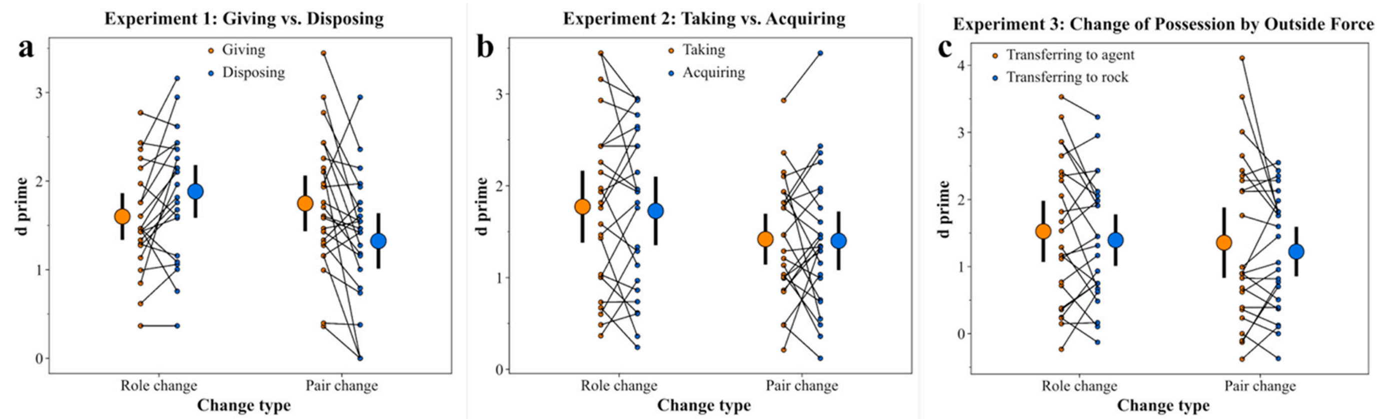

Fig. 2. Sensitivity (*d*') of detecting changes of displayed events in Experiment 1 (a), Experiment 2 (b), and Experiment 3 (c). The black dots indicate *d*' values for each participant in each condition and are connected for paired values. The large circles and the vertical lines denote the means and the confidence intervals (CI) of the means within each condition.

The evidence earlier reviewed suggests that adults and infants do not necessarily include the prior possessor of a taken object as event participant (Tatone et al., 2015; Yin et al., 2020), at least not when the possessor appears unreactive (cf. Gazes, Hampton, & Lourenco, 2017; Tatone & Csibra, 2020). This asymmetry is likely due to the fact that the goal of taking, unlike giving, can be apprehended by directly appealing to the rewards of object acquisition, without having to factor in the effects of this action on the original possessor of the object. If adults do indeed tend to represent taking as a nonsocial act of object acquisition (a two-place event of the 'A takes X' type), we should expect comparable patterns of change sensitivity for *taking* (i.e., collecting an object from an animate target) and *acquiring* (i.e., collecting an object from an inanimate target). If such is the construal that adults adopt across event types, we should also expect change sensitivity to be modulated by change type: specifically, we predicted adults to show higher sensitivity to role change and a lower sensitivity to pair change. This is because, while detecting a change in a role-change event only requires assessing whether the a centrally encoded agent (i.e., the one acquiring the object) featurally matched any of the previous agents (as in the disposing event of Experiment 1), detecting a change in a pair-change event requires determining whether the active agent was in the same event as the passive one, which, by hypothesis, should have been peripherally encoded irrespective of its event role (patient vs. bystander).

3.1. Methods

Twenty-four adult paid volunteers (15 males and 9 females; mean age = 21 years, age range = 18–25 years) participated in this experiment. The methods and design were the same as in Experiment 1. The events presented in Experiment 2 consisted in the active agent collecting the apple either from the passive agent (*taking*) or from the rock (*acquiring*). Apart from the direction of transfer, the only other difference from the transfer events used in Experiment 1 was the starting location of the apple (next to the rock or the passive agent).

3.2. Results & discussion

An ANOVA on the *d*' values conducted in the same way as in Experiment 1 revealed only a main effect of change type ($F(1,23) = 7.65$, $p = .011$, $\eta_p^2 = 0.25$, $BF_{10} = 27.21$), which showed that change sensitivity was higher for role change ($M = 1.75$; $SD = 0.86$) than pair change ($M = 1.41$; $SD = 0.64$; 95% CI of mean difference = [0.09, 0.59]). Neither the main effect of action type ($F(1, 23) = 0.17$, $p = .686$, $\eta_p^2 < 0.01$, $BF_{10} = 0.22$) nor the interaction ($F(1, 23) = 0.02$, $p = .885$, $\eta_p^2 < 0.01$, $BF_{10} = 0.27$) reached significance.

To further investigate whether change sensitivity was affected by the type of object-displacing action observed, a 2 (action type as a between-subjects factor: transferring [Experiment 1] vs. collecting [Experiment 2]) × 2 (target as a within-subject factor: patient vs. rock) × 2 (change type as a within-subject factor: role change vs. pair change) ANOVA was conducted on the *d*' data, yielding a three-way interaction: $F(1, 46) = 7.47$, $p < .001$, $\eta_p^2 = 0.14$, $BF_{10} = 4.34$. This was due to a two-way interaction between target and change type in Experiment 1, which was not found in Experiment 2. This result shows that the type of object-displacing action observed (transferring vs. collecting) differentially affected the participants' sensitivity to change type depending on whether the action could be represented as interactive relative to its noninteractive counterpart (disposing for giving; acquiring for taking).

As predicted, sensitivity to change was not influenced by event type (taking vs. acquiring), but only by change type in the prediction direction. These results allow us to confidently rule out the possibility that the binding of active and passive agents observed in Experiment 1 have been induced by non-specific cues of social approach, irrespective of concomitant transfer, or by the perception of a transferring action, irrespective of its nature.

Consistent with the interpretive asymmetries discussed earlier (Yin et al., 2020), the contrast between Experiment 1 and 2 suggests a different propensity to assign patienthood between giving and taking events: a passive agent is easier to be interpreted as a patient when the agent transfers an object to it than when the action collects an object from it.

4. Experiment 3: Change of possession by outside force

In Experiment 1 we interpreted the higher sensitivity to pair changes for giving events as evidence of binding prompted by the perception of a social interaction. Although Experiment 2 ruled out the possibility that this binding was due to cues of social approach, it is nevertheless possible that the binding of active and passive agent in Experiment 1 was due to highlighting the passive agent at the endpoint of the object's trajectory, irrespective of any action (cf. Lakusta & Landau, 2012; Regier & Zheng, 2007). Experiment 3 was designed to address this possibility. The participants were presented with the same events of Experiment 1, with the only difference that an external effector (a mechanical hand) transferred the object to either target without the involvement of the agent. Such manipulation allowed us to remove any action directly relating an agent to a patient while preserving the attentional highlighting of the two agents through the object's motion.

4.1. Methods

Twenty-four adult paid volunteers (11 males and 13 females; mean age = 20 years, age range = 17–25 years) participated in this experiment. The methods were the same as those of Experiment 1, except that the two agents remained motionless, while the apple was transferred by a mechanical hand (Fig. 3). In this case, the two types of events were labelled as *transferring to agent* and *transferring to rock*.

4.2. Results & discussion

The ANOVA on the *d*' values revealed that no effects (action type: $F(1, 23) = 1.58$, $p = .222$, $\eta_p^2 = 0.06$, $BF_{10} = 0.44$; change type ($F(1, 23) = 2.81$, $p = .107$, $\eta_p^2 = 0.11$, $BF_{10} = 0.72$; interaction effect ($F(1, 23) < 0.01$, $p = .990$, $\eta_p^2 < 0.01$, $BF_{10} = 0.30$). A between-experiment comparison with Experiment 1 yielded a significant three-way interaction ($F(1, 46) = 6.80$, $p = .012$, $\eta_p^2 = 0.13$, $BF_{10} = 4.33$), suggesting that change sensitivity was critically modulated by the presence of a social interaction (i.e., active giving).

These results suggest that the encoding of the two agents in Experiment 1 could not be explained in terms of an association induced by their attentional highlighting via object motion. The comparison with Experiment 2 is also informative: the lack of a main effect of change type suggests that when the central agent did not perform any action, the encoding advantage for this agent relatively to the passive one was abolished, thereby ruling out the possibility that its encoding advantage may have been due to factors other than the action itself (e.g., the agent's location).

5. General discussion

The present study examined how adults spontaneously represent nonlinguistic giving and taking events. We presented participants with a series of object-displacing actions directed at a passive agent (animate target) or a rock (inanimate target) and tested their ability to detect changes in these events. We reasoned that actions prompting an interactive construal should lead participants to bind active and passive agent when the latter could be meaningfully assigned to the role of patient. If so, we expected change sensitivity to be modulated by whether the action was directed at the animate or inanimate target.

This was indeed the case when participants were presented with a *transferring* action (i.e., the agent pushes an object towards the target: Experiment 1): when the action was directed at the passive agent, participants were better at detecting whether the two agents previously appeared in the same event (pair change), and worse at detecting whether they occupied the same role (role change). The target-specificity of this effect suggest that binding occurred only when the agent and patient could be respectively represented as agent and patient.

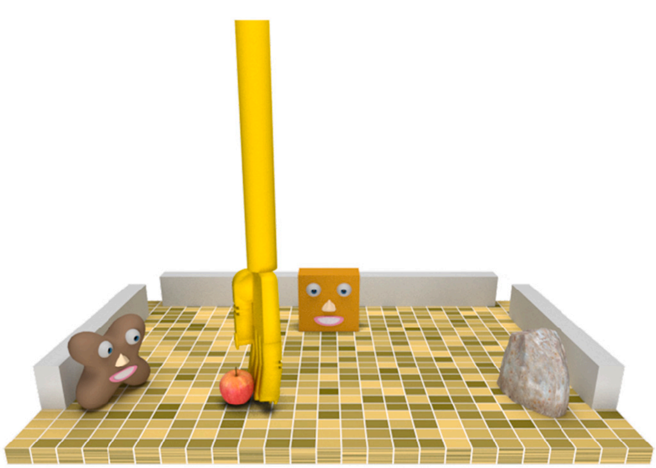

Fig. 3. Illustrative example of the stimuli used in Experiment 3 showing the apple being transferred by the mechanical hand.

However, when participants were presented with a *collecting* action (i.e., the agent pushes an object away from the target, as in Experiment 2), change sensitivity was not modulated by target type, but only by change type: participants were more sensitive to role change than pair change overall. The lack of target-specific effects shows that the role that the passive agent occupied in collecting events (as potential patient or mere bystander) did not influence its encoding. Consistent with this hypothesis, the main effect of change type suggests that participants were better at detecting a change in the attentionally prominent (and thus centrally encoded) active agent compared to the passive (peripherally encoded) agent.

The results of Experiment 2 thus allow us to conclude that the binding effect observed in Experiment 1 was neither induced by generic cues of social approach (i.e., seeing an agent moving towards another), nor it generalized to superficially similar object-displacing actions, such as taking, which could be also potentially interpreted in interactive terms (i.e., as directed to a patient). Finally, when the events featured a transferring action caused by an outside force, without the involvement of either agent, change sensitivity was not affected by either target or change type (Experiment 3), further ruling out the possibility that the attentional highlighting of the two agents as source and endpoint of the object's motion in the giving event may have contributed to their binding in Experiment 1.

Taken together, these results show that the observation of giving, but not taking, selectively induced the binding of agent and patient. Despite their surface similarities, the two actions invited structurally different construals: a purely instrumental one for taking, which only includes the agent acting on the object; and an interactive one for giving, which further specifies a patient benefitting from the transfer. These findings corroborate the results of a previous EEG study (Yin et al., 2020), which provided initial evidence for such an interpretive asymmetry in adults using nonlinguistic stimuli, and expand upon them in two respects. First, our findings show that differences in event construal influence not only online action processing, but also the maintenance and retrieval of event-relevant information in WM (Paparella & Papeo, 2022; Vestner et al., 2019). Second, our results suggest that adults interpret giving in dyad-specific terms: i.e., as evidence of a particular social interaction between two agents ('A gives X to B') rather than of an individual and recipient-invariant disposition ('A is a Giver'), as the sensitivity to changes in pair composition showed.

The tendency to construe giving but not taking in interactive terms, and to infer from the former a dyad-specific association have both been documented in infancy (Tatone et al., 2015; Tatone & Csibra, 2020). The convergence of the present results with the developmental data suggests that these asymmetries in event construction may reflect prelinguistic assumptions about the minimal number of event participants that giving and taking entail (Wellwood, Xiaoxue He, Lidz, & Williams, 2015). Nevertheless, we cannot rule out the possibility that our participants relied on an implicit linguistic encoding of the two transfer events, and that, consequently, the asymmetry documented here may have been due to linguistic differences in the structuring of these events. An adequate test of this possibility would require making participants unable to recruit phonological resources during event apprehension (as in verbal-shadowing paradigms: Paparella & Papeo, 2022). We remain provisionally wary of this conclusion, for two reasons. Firstly, it seems more parsimonious to expect early-emerging nonlinguistic biases in event construction, as those evinced in preverbal infants, to affect the syntactic prominence of patients in adults as well, rather than assuming these biases to be later supplanted by a conceptually homologous, but purely linguistic, phenomenon (Strickland, 2017). Secondly, the asymmetry was first observed in an EEG task (Yin et al., 2020) where adult participants were given an incidental task (i.e., counting the number of truncated animations) that did not require them to pay attention to, or memorize, the type of action observed.

This asymmetry, however, should not be taken to suggest that adults (or infants) fail to appreciate the social consequences of taking, but only that the seizing of an object from a passive agent is not sufficient evidence to induce the integration of this participant in the event. That is, the minimal conditions for assigning patienthood seem to differ for giving and taking: if the former only requires an animate agent in proximity of the transferred object to fulfill the role of Givee (Meristo et al., 2015; Tatone, Hernik, & Csibra, 2019; Tatone et al., 2021), the latter may necessitate of further cues of overt affectedness for an agent to be considered a Takee (as in: Gazes et al., 2017; Meristo & Surian, 2014; Hamlin & Wynn, 2011). In fact, when presented with familiar stimuli (e.g., humans) and more explicit operationalizations of possession (e.g., holding onto an object), infants and adults represent taking in a three-place structure (Chen, Papafragou, & Trueswell, 2022; Perkins, 2019). In light of this evidence, the documented asymmetry may be recast to suggest that proximity becomes an informative cue of possession only when actively established. Under this reading, giving was interpreted as patient-directed in Experiment 1, because the object was brought into the patient's proximity, inducing the ascription of a new possession relation (and thus motivating the patient's inclusion in the event). Taking, on the other hand, was not interpreted as patient-directed, because the patient did not actively enter in proximity with the object, and therefore was perceived as its possessor.

The convergence of the infancy data with the current findings has noteworthy implications for cognitive linguistics. GIVE and TAKE differ across languages in their syntactic requirements, with the former requiring the patient argument to be made syntactically explicit, and the latter not (Kittila, 2006; Newman, 2005). This difference has been traditionally explained in terms of distribution of semantic roles: in GIVE agent and patient refer to distinct participants, whereas in TAKE they refer to the same participant – the Taker, who is at once the agent causing the transfer and experiencing its effects (Newman, 1996). Such an explanation is however question-begging, as it excludes a priori the Takee as a possible candidate for a dedicated participant role (i.e., as the patient experiencing the loss of her possession). In light of the developmental data, we believe that the difference in linguistic elaboration reflects the operations of an action-interpretation system geared to select the minimal number of participants necessary for an action to be teleologically well-formed, given the goal hypotheses that the interpreter can choose among. Under this explanation, the facultative inclusion of the patient in a taking event is due to the fact that, unlike in giving, a structurally simpler goal hypothesis is readily available to explain the agent's action – namely, as merely directed to the acquisition of an object.

The proposal that syntactic regularities may be partly rooted in early-emerging forms of non-linguistic thought has been advanced to explain similarities between morphosyntactic structures and semantically salient concepts across domains such as mass/count distinction and numerical classifiers (for a review: Strickland, 2017; Strickland & Chemla, 2018). More recently, this idea has been further championed to explore homologies between conceptual and linguistic event roles in the interpretation of transitive actions. For instance, children's tendency to mention specific participants in a picture-description task was found to correlate with their propensity to detect changes in these participants in a change-detection task, consistently with the predictions of the Thematic Hierarchy model (in which agents play the most prominent role, followed by patients, goals, and instruments: Ünal, Richards, Trueswell, & Papafragou, 2021; Ünal, Ji, & Papafragou, 2021; Rissman & Majid, 2019). Complementing this model, our work suggests that the degree to which certain participants are psychologically foregrounded crucially depends on the type of action observed, at least within the domain of transferring actions (Gentner, 1975).

The present research also charts new territories in the literature on social binding. Several studies have shown that adults spontaneously use visuospatial cues of ongoing or potential interactions, such as facingness, to organize the representation of static multi-agent displays into interactive units (Paparella & Papeo, 2022; Papeo, Goupil, & Soto-Faraco, 2019; Vestner et al., 2019). This research has mostly focused on the rapid and perceptually grounded detection of socially relevant configurations independent of and prior to any actual interaction. A common finding of this literature is that, even before an interaction is fully realized or understood (e.g., the agents' complementary roles fail to conform to any interaction schema: Paparella & Papeo, 2022), people perceive two agents facing one another as a social unit, with direct consequences for attentional orienting, visual search, and encoding. The present study, instead, demonstrated that even when two events bear identical interaction affordances (e.g., social approach or proximity), action-specific assumptions may influence the extent to which participating agents are perceived as interactively related. The evidence that facingness suffices to promote chunking seems to be at odds with our results in Experiment 2, which suggested that participants did not include passive agents in the representation of taking events, even if directly approached. This contradiction, however, is only apparent. If facingness provides a perceptual prior for assuming that an interaction may be established, the instrumental construal of taking (as object-directed) supplies an interpretive prior against such assumption (insofar as the presence of the passive agent is redundant to explain the agent's action as goal-directed). As such, our findings should not be taken to suggest that people may not perceive cues such as facingness or social approach as indicative of potential interactions. Rather, they suggest that the availability of goal hypotheses that make specific event participants superfluous to the representation of certain action goals ('A takes X') influences the strength of their encoding. Properly understood, these two bodies of research in fact complement each other. Where the work of Vestner, Papeo, and colleagues focuses on a "first-pass analysis" that concerns the detection and encoding of relationally relevant visuospatial configurations (Paparella & Papeo, 2022; Papeo, 2020; Vestner et al., 2019), our studies highlight the downstream effects that goal interpretations have on argument encoding and event structuring.

Nevertheless, there are seeming discrepancies between our results and prior findings on social chunking that need addressing. If the higher sensitivity to pair changes in giving (relative to disposing) obtained in Experiment 1 is largely consistent with previous studies suggesting that grouping two agents in an interactive unit enhances the encoding and recall of agent-identifying features (e.g., Vestner et al., 2019), the lower sensitivity to role change appears to contradict Ding et al. (2017), which showed that social chunking *boosts* action encoding. This discrepancy is due to crucial differences in task design and parameter space. In Ding et al. (2017), participants were exposed to a single memory event consisting of a number of agents arranged in interactive or non-interactive pairs ("interactivity" here denotes to the semantic congruence of role pairings) and had to decide if an action at test was previously shown or not. Critically, since the stimuli did not include featurally distinct agents (as these consisted of indistinguishable point-light displays), the only information that participants could respond to at test concerned the action performed. Properly framed, Ding et al.'s findings thus show that the perception of social interactions boosts the encoding of action roles, absent other socially relevant information to be tracked. In contrast, in our study participants were presented with four memory events, each containing two featurally distinct agents, and tasked with detecting whether the identity of the agents at test and their individual action roles matched any of the memory events. Doing so required encoding the identity of the agents and their roles within each sequentially presented dyad (e.g., AB, CD). The higher sensitivity to pair changes and the weaker sensitivity to role changes for giving over disposing events may then suggest that, when prompted to monitor *multiple* dyadic interactions, people prioritize the encoding of the participating agents' identities within each over their action roles. From a task-analysis perspective, such a hierarchy of representational goals makes compelling sense: one must first ensure that dyads are appropriately identified and segregated from one another (e.g., A goes with B, and C with D) and only then assign individual roles within each (e.g., A gives to B), else promiscuous pairings would occur. Without partitioning the social landscape into discrete relational units, leveraging information about individual action roles is on its own useless,unless taken to diagnose an agent's stable and recipient-invariant disposition (e.g., "A is a generous person"). Furthermore, the relatively weaker encoding of action role information is also consistent with recent developmental evidence suggesting that giving may prime the representation of reciprocal long-term relations, within which participants are expected to swap roles over time (Tatone et al., 2019; Tatone & Csibra, 2020). In sum, far from suggesting that the perception of giving may inhibit the representation of action roles (cf. Hafri et al., 2018), our results suggest that the encoding of information relevant to tracking dyads (i.e., the identity of the participating agents) is prioritized when multiple interactions need to be maintained in WM.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cognition.2022.105248.

CRediT authorship contribution statement

Jun Yin: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft. **Gergely Csibra:** Conceptualization, Writing – review & editing. **Denis Tatone:** Conceptualization, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

None.

Data availability

Data and supplementary videos are publicly available via the Open Science Framework, and can be accessed at: https://osf.io/zwgrd/?view_only=0f91e593d6ce4d09a438fe8eac57ff6f.

Acknowledgements

This work was supported by the Major Support Project for the Emerging Cross-Discipline of Philosophy Social Science Foundation of Zhejiang Province (21XXJC05ZD), an Advanced Investigator Grant of the European Research Council (#742231, PARTNERS), and the National Natural Science Foundation of China (Grant no. 31871091).

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