

What can a cook in Italy teach a mechanic in India?

Action Recognition Generalisation Over Scenarios and Locations

Supplementary Material

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Abstract

This document is divided into six sections. Section A provides additional details on dataset curation. Section B provides additional ablations: Sec B.1 ablates λ_1 and λ_2 parameters, which are used to weight the loss terms. Section B.2 provides results of CIR on different seeds. Section B.3 provides complete ablations on support set size. Additional details on the hyper-parameter search are then provided in Section C. Section D provides a description of the qualitative video of results available online. Finally, Section E provides the expanded version of the Table 5 in the main paper.

A. Dataset Curation

In this section we detail our pipeline for curating ARGO1M. The process has three steps, (i) scenarios (A.1), (ii) clip selection (A.2), and (iii) action classes (A.3).

A.1. Scenarios

We discard Ego4D videos with a missing scenario description (7.4% of the total videos). Then, from the total of 136 free-form descriptions of scenarios provided by Ego4D, we choose the 62 that contain sufficient diversity and number of videos, excluding those that are repetitive and not representative of a specific activity, such as “Talking,” or “On a screen”. This results in a set of 6813 videos, which represents 83.1% of the videos with at least one associated scenario. We also exclude videos marked to contain multiple scenarios.

We group the remaining scenario descriptions into 10 scenarios, each one containing similar activities, *e.g.* “brewing coffee” and “making a sandwich” both belong to the scenario *Cooking*. The resulting clustered scenarios are shown in Table 1.

^{*}Work carried during Chiara’s research visit to the University of Bristol

A.2. Video Clips

Each selected video is provided with timestamp-level narrations, which describe the camera wearer’s actions and interactions with objects, for example the narration “#C C puts the scraper down” with the timestamp 3.70s. We chose narrations from *annotator_1*, and only select actions which correspond to the camera-wearer, *i.e.* those with narration tagged with #C, ignoring those corresponding to actions performed by an external actor (tagged with #0). We use a set of heuristics to filter out videos whose scenario metadata originally provided by Ego4D is incorrect. We do this by identifying a set of keywords that we expect to find in the corresponding scenario across video’s narrations. We only keep videos whose narrations contain these keywords relevant to the scenarios which we manually curate. This yields a set of 6358 videos (93% of the videos from the selected scenarios) and 1,637,810 narrations.

Narrations in Ego4D are well-aligned with videos due to the use of a pause-and-narrate annotation procedure. This is noted in the Ego4D paper and by others [7]. To verify, we manually annotated action start times on a small subset and found an average offset of 0.6s between our action start times and the narration timestamps, and 0.9s between their endings. This allows us to take the narration timestamp as the clip start time, and the timestamp of the next narration as the clip end time. Like prior efforts, where action boundaries can be more relaxed given they contain the relevant action (*e.g.* Kinetics [1]), we find these boundaries to be sufficient for training and evaluation of action recognition. We next describe how clips are associated with class labels.

A.3. Action Classes

Action labels are extracted from the verbs in the Ego4D narrations using spaCy [5]. We parse narrations into verbs and nouns. We take the verb as the candidate action, and group these verbs using the EPIC-KITCHENS-100 [2] taxonomy, with some manual changes to handle the larger range of activities in Ego4D (Table 6). For example, similar

Scenario	Ego4D Descriptions
Cooking	BBQing/picnics, Baker, Cooking, Making coffee, Outdoor cooking
Building	Carpenter, Fixing something in the home, Handyman, Making bricks, Jobs related to construction/renovation company (director of work, tiler, plumber, electrician, handyman, etc)
Arts and crafts	Crafting/knitting/sewing/drawing/painting
Cleaning	Car/scooter washing, Cleaning / laundry, Cleaning at the gym, Community cleaning, Daily hygiene, Household cleaners, Washing the dog / pet or grooming horse
Mechanic	Assembling furniture, Bike mechanic, Blacksmith, Car mechanic, Fixing PC, Getting car fixed, Labwork, Maker Lab (making items in different materials, wood plastic and also electronics)- some overlap with construction etc. but benefit is all activities take place within a few rooms, Scooter mechanic, Working at desk, Biology experiments
Gardening	Doing yardwork / shoveling snow, Farmer, Flower picking, Gardener, Gardening, Potting plants (indoor)
Playing	Assembling a puzzle, Gaming arcade / pool / billiards, Playing darts, Playing board games, Playing cards, Playing games / video games, Practicing a musical instrument
Shopping	Clothes and other shopping, Grocery shopping indoors, Working in milktea shop, Working in outdoor store
Sport	Attending sporting events - watching and participating in, Baseball, Basketball, Bowling, Climbing, Cycling / jogging, Football, Going to the gym - (exercise machine, class, weights), Golfing, Hiking, Playing badminton, Roller skating, Rowing, Swimming in a pool/ocean, Working out at home, Working out outside
Knitting	All videos from <i>Arts and crafts</i> scenario, where <i>at least</i> one narration contains keywords related to knitting activities.

Table 1: Our closed-form scenarios for ARGO1M, and corresponding Ego4D free-form descriptions.

actions such as “take” and “pick” are grouped into one class. We exclude ambiguous actions (*e.g.* “adjust”) and those which do not interact with the surroundings (*e.g.* “look at”). We also exclude actions which occur too infrequently to train for domain generalisation. This process leaves a set of 60 action classes (shown in Fig. 2 in the main paper) and 1,050,371 instances.

ARGO1M accordingly has 1,050,371 video clips from 5894 videos, which correspond to 42% of all Ego4D clips and 61% of all selected videos in Ego4D.

Note: While curating ARGO1M, we noticed a common pattern throughout Ego4D narrations: the actions “put” and “drop” were often used interchangeably, and often incorrectly. We hypothesise this is a result of non-native narrators, but could be due to the subjective choice of words. When we examined the average statistics on the validation set, we found that the network incorrectly predicted “put” instead of “drop” for approximately 16% of the total number of “drop” samples, and incorrectly predicted “drop” instead of “put” around 10% of the time. We acknowledge these annotation inconsistencies as a limitation. There might be other limitations in narrations we are not aware of. Importantly, we believe these ambiguities offer good practice in avoiding clips that achieve easy consensus. This allows for videos that present more challenging situations

where actions are difficult to recognise [8].

A.4. ARGO1M Feature Distribution

Figure 1 visualises the feature distribution of all samples in ARGO1M across scenarios (left), geographic locations (center) and action classes (right). For better clarity, in the action class plot we visualise 3 out of 60 classes and indicate the remaining ones as *others*. These features are obtained by a SlowFast network [3] pre-trained on Kinetics [1] and are visualised through UMAP.

There is evidence of *scenarios clustering in different locations*, *e.g.*, *Playing* (green cluster at the right of the feature map) corresponds to different locations (*United Kingdom, Minnesota and Indiana*), and *locations clustering in different scenarios*, *e.g.*, *Minnesota* (yellow cluster on the right) corresponds to multiple scenarios (mostly *Cleaning* and *Shopping*). This shows that scenario and location shifts cannot be handled independently or disentangled easily, and that considering (scenario, location) pairings as test domains better captures the combined scenario/location shift properties.

While it is easy to distinguish clusters of scenarios and locations, action classes are spread. We show that with the three actions ‘take’, ‘cut’ and ‘wash’ that all are spread across the feature map. This shows the complexity of the

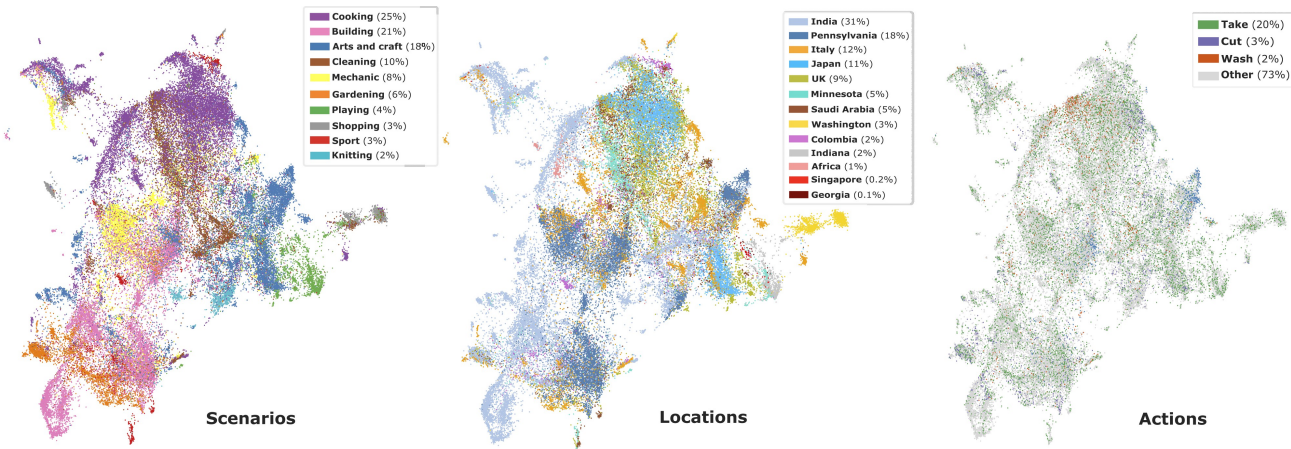


Figure 1: UMAPs of ARGO1M features across scenarios (left), locations (center) and for three action classes (right). We use the same projection to show correspondence across the three UMAP plots.

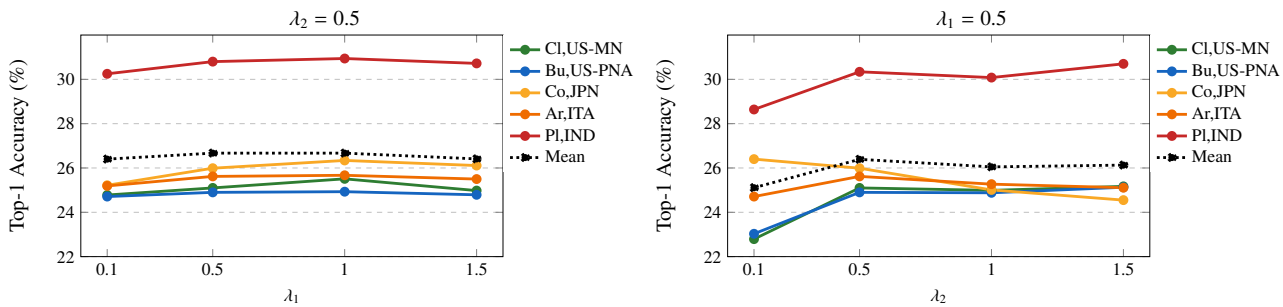


Figure 2: Average Top-1 accuracy of CIR, over test splits, as we vary the loss weighting hyper-parameters. Left: Varying λ_1 (left) while keeping $\lambda_2 = 0.5$; as well as varying λ_2 (right) while keeping $\lambda_1 = 0.5$.

proposed generalisation task.

B. Additional Ablations

We use the **validation set** to select the best hyper-parameters for each algorithm. For each split, the validation set is a random 10% of the training set, and thus contains no examples from the test scenario nor location. Importantly, the split is on video basis, meaning that all clips from the same video are jointly present in either the training or the validation sets. We consider the performance over the split with biggest training and validation set (**PI, US-IND**) for hyper-parameter optimisation.

B.1. Ablation on λ values

We assess how CIR results vary as we change λ_1 and λ_2 , which weigh \mathcal{L}_{rt} and \mathcal{L}_{rc} respectively (Eq. 5 of the main paper). For hyper-parameter selection, we chose the λ_1 and λ_2 values achieving the best results on the validation set ($\lambda_1=1, \lambda_2=0.5$). In Fig. 2, we plot performance as we vary both λ_1 and λ_2 on the test splits. We average performance on the test splits that we use for ablations in the main paper. When λ_1

variations are shown, λ_2 is set to 0.5, and vice-versa. Overall, performance is more sensitive to λ_2 than λ_1 . In both cases, performance drops for lower and higher values.

Seed	Method	CI	Bu	Co	Ar	PI
		US-MN	US-PNA	JPN	ITA	US-IN
0	ERM	22.35	20.73	24.81	22.75	23.29
	MMD	23.60	22.08	25.87	23.84	24.78
	CIR	25.51	24.93	26.34	25.67	30.94
1	ERM	22.31	21.09	25.29	22.91	23.91
	MMD	23.87	22.51	25.70	23.81	24.66
	CIR	25.39	25.01	25.83	25.79	30.41
2	ERM	22.30	20.86	24.89	22.91	23.40
	MMD	23.66	22.36	25.92	23.59	24.60
	CIR	25.69	25.02	26.01	25.66	30.42
3	ERM	22.43	20.41	25.14	23.12	23.68
	MMD	23.66	22.22	25.96	23.60	24.53
	CIR	25.49	25.05	26.16	25.28	30.41

Table 2: Results of ERM and CIR on 4 different seeds.

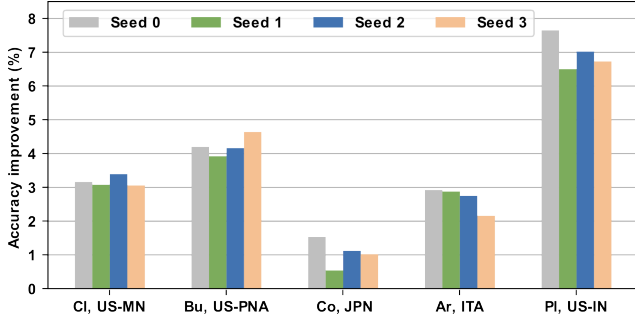


Figure 3: Improvement (%) of CIR w.r.t. ERM on the different seed. Main results are on seed 0, where the best ERM results are achieved on the validation set.

	CI US-MN	Bu US-PNA	Co JPN	Ar ITA	PI US-IN	Mean
16	23.90	22.99	26.04	23.87	28.46	25.05
32	23.54	22.78	26.40	24.38	28.12	25.05
64	23.89	24.36	26.54	24.98	28.97	25.75
128	25.51	24.93	26.34	25.67	30.94	26.68
256	25.00	24.97	26.52	25.96	30.61	26.61
512	24.95	24.82	26.15	24.02	30.88	26.16
1024	24.64	25.31	25.79	25.87	30.70	26.46
2048	24.66	24.73	25.48	25.53	30.27	26.14

Table 3: Effect of varying the batch size on CIR.

B.2. Seed variations

All the results in the main paper are compared on one fixed seed for direct comparison across baselines. We select the seed achieving best results on ERM by optimising on the validation set (seed 0). To show performance stability, we run results of ERM, CIR, and MMD (the best performing baseline) on 4 seeds. In Table 2, we showcase the results confirming CIR is consistently achieving best performance on every split and every seed. For easy comparison, we plot the relative improvement of CIR over ERM over all seeds and on the five largest test splits in Fig. 3. Figure shows consistent improvement over ERM across the seeds.

B.3. Support-Set Size

Due to space limitations, we do not include all batch sizes in the ablations of Table 5 in the main paper. We provide the complete set of results in Table 3. Results showcase continuous improvement as we increase the batch size up to 128, with a slight drop for larger batches.

C. Hyper-parameter search

In Table 4 we show the hyper-parameter search space for each of the baseline methods, highlighting the chosen hyper-parameters in **bold**. For CORAL [9], MMD [6], DANN [4], BoDA [11] and DoPrompt [12], the overall loss

Method	Hyper-parameter	Grid Search
CORAL	γ_1, γ_2	{0.1, 0.5, 1, 1.5} , {0.1, 0.5, 1, 1.5}
MMD	γ_1, γ_2	{0.1, 0.5, 1 , 1.5}, {0.1, 0.5 , 1, 1.5}
DANN	γ_1, γ_2 Adam β_1	{0.1, 0.5, 1, 1.5} , {0.1, 0.5, 1, 1.5} 0.5
Mixup	α	{0.1, 0.2 , 0.5}
BoDA	γ_1, γ_2 nu	{0.1, 0.5, 1, 1.5} , {0.1, 0.5, 1, 1.5} 1
DoPrompt	γ_1, γ_2 l	{0.1, 0.5, 1 , 1.5}, {0.1, 0.5, 1 , 1.5} {4, 16, 32}

Table 4: Hyper-parameter search space for different algorithms. Best ones are in **bold**.

	ERM	CORAL	DANN	MMD	Mixup	BoDA	DoPrompt
LR	10^{-4}	10^{-5}	10^{-5}	10^{-5}	10^{-5}	10^{-5}	10^{-6}

Table 5: Chosen learning rate (LR) for each baseline method.

is $\mathcal{L} = \mathcal{L}_c + \gamma_1 \mathcal{L}_{scen} + \gamma_2 \mathcal{L}_{loc}$, where \mathcal{L}_c is the cross-entropy loss and \mathcal{L}_{scen} and \mathcal{L}_{loc} are the losses from these methods applied to scenarios and locations respectively. For example, \mathcal{L}_{scen} is the MMD loss between scenarios when training MMD. For domain-alignment methods (MMD, CORAL, BoDA), we apply the scenario and location alignment loss on the last layer features.

For BoDA, we also set the hyper-parameter nu controlling the calibration distance to nu = 1 (see details in [11]).

The discriminator-based method DANN utilises two domain discriminators, consisting of 2 fully connected layers each. One discriminator is responsible for classifying scenarios, and one for classifying locations. Each of them has a gradient reversal layer with momentum term $\beta_1 = 0.5$ ¹.

For DoPrompt, we learn two separate prompts, one for each scenario, and one for each location. In addition to the weights γ_1 and γ_2 used for prompt learning, we also perform a grid search on the prompt length l.

For Mixup [10], which is the only baseline method that does not require domain labels, we perform an optimisation of the hyper-parameter α controlling the interpolation of mixed samples.

For each method, we also optimise the learning rate in a search space of $\{10^{-6}, 10^{-5}, 10^{-4}, 10^{-3}\}$. We show in Table 5 the chosen learning rate (LR) for each baseline method.

D. Qualitative Results

In the video of qualitative results available at <https://chiaraplizz.github.io/what-can-a-cook/>, we visualise reconstructed instances from the training set by CIR and their support set, which correspond to the examples in

¹We followed A. Radford et al., Unsupervised Representation Learning with Deep Convolutional Generative Adversarial Networks. ICLR 2016

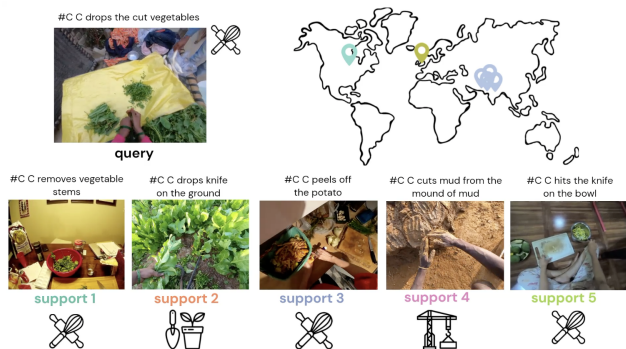


Figure 4: Preview of the video of qualitative results.

Figure 8 of the main paper. A preview of the video is shown in Fig. 4. On the top left, we show the query video clip, along with the corresponding narration (top of the video), scenario (icon on the top-right of the video), and location (pin on the top-right map). Note that pin colours correspond to location colours in Fig. 2 of the main paper. On the bottom row, we show the j -th support video clip, along with its narration (top of the video), scenario (icon below) and location (pin on the map).

The video, as in Figure 8 of the main paper, aims to showcase how one video clip during training is reconstructed from other video clips in the batch, potentially from other scenarios and/or locations.

E. Expanded version of Table 5

Class	Open-vocabulary Verbs
take	<p>takes-along, takes-out, take-off, takes-inside, takes-at, takes-behind, takes-around, takes-underneath, cc-takes, takes-without, take-with, takes-for, take-out, takes-from, takes-back, takeout, takers, takes-near, takes-into, takes-against, takes-like, takes-of, takes-by, takes-to, takes-toward, takes-beside, takes-below, take-at, takes-on, takes-towards, takes-down, takes-over, take-from, take, takes-among, takes-up, takes, partakes-in, takes-under, takes-fro, takes-in, takes-atop, takes-outside, overtakes, takes-off, takes-beneath, take-in, takes-with, pickes-on, picks-atop, picks-as, picks-by, picked-at, picking, picks-around, picks-near, pickup-from, picks-at, picks-fro, picked, picks-against, picks-down, picks-below, picks-on, picks-over, picks-without, cpicks, picks-beside, picks-into, picks-beneath, pick-from, picks-inside, picked-from, picks-for, picksfrom-with, picks-before, picks-back, picked-up, picking-from, picks-off, picks-from, picks-amongst, pick-on, picks-with, picked-with, picks-to, picks-outside, picka, pick-out, pick, pick-up, picking-on, picks-fom, picks-out, picks-under, picks-amidst, picks-up, pick-in, picks-toward, pick-with, pickes-with, picks, picks-onto, picking-up, picks-in, picks-underneath, picks-of, picks-wit, picked-on, picks-behind, picked-of, picked-beside, pickss-with, fetches-inside, fetches-into, fetch-with, fetch, fetches-with, fetches-to, fetches, fetches-under, fetches-from, fetchs, fetches-on, fetching-into, fetches-in, fetch-in, grabs-in, grabs-at, grabs-beside, grabbed, grabs-from, grabs-around, grabs-below, grabs-within, grabs-inside, grabs-for, grabs-on, grabs-of, grabs-with, grab, grabs, grabs-off, grabs-by, grabs-under ,gets-from, pull-off, pulls-off, draws-out</p>
put	<p>puts-through, puts-agaisnt, put-of, inputs-into, puts-off, put-in, put-from, puta-into, puts-at, put-over, put-back, put-into, puts-alongside, puts-behind, putts, put-to, putting, [puts, put-down, puts-among, puts-under, puts-together, putting-on, put-under, puts-round, puts-beside, puts-to, puts-inot, puta-down, puts-away, puts-out, puts-against, put-on, puts-beneath, putting-in, puta-on, puts-n, puts-between, puts-towards, puta-in, sheputs-down, puts-underneath, puts-below, put-at, puts-of, put, puts-near, putting-down, oputs-in, put-underneath, p[puts-on, puts, puts-aside, puts-in, put-inside, put-beside, puts-with, puts-back, puts-into, inputs-on, puts-from, puts-by, puts-across, puts-around, put-between, puts-over, putting-into, puts-along, puts-above, puts-onto, puts-on, puts-down, puta, sheputs-in, puts-inside, places-round, places-onto, places-below, place-for, places-before, places-from, sheplaces, place-under, displaces-on, replaces-on, placers, places-by, places-underneath, places-under, places-at, places-back, places-with, places-near, placed-in, places-within, replaces-into, place-with, places-across, places-off, replaces-to, placed-beside, places-infront, places-behind, places-through, places-opposite, replace, place-on, sheplaces-on, replaces-with, places-against, replaces-from, places-of, placed, places-among, placers-on, places-over, placed-under, place, places-like, placers-down, places-along, places-above, places#unsure-on, places-towards, places-atop, replaces, placed-with, displaces, places-down, places-into, place-into, places-beneath, places-beside, place-in, places-in, replaces-in, places-around, places-to, displaces-with, places-up, places-on, places-for, places-inside, places-between, place-down, placed-on, places, places-out, places-unto, displaces-in, repositions-against, reposition-in, positions-on, positions-under, repositions-with, repositions-in, reposition-with, repositions-across, repositions-on, repositions-at, repositions-amongst, positions-inside, repositions-out, positions-beside, positions-at, positions-along, repositions-under, positions-with, repositions-from, reposition, repositions-to, positions-against, repositions, positions-in, positions, repositions-atop, repositions-up</p>
drop	<p>drops-off, drop-inside, drops-amongst, dropped-in, drops-om, drops-across, drops-outside, drops-forth, drops-back, dropes-into, dropes-in, drops-with, drops-from, drops-under, drops-infront, drops-by, shedrops-in, dropes, drop, drops-on, drops-like, drops-oon, drops-to, drops-in, drop-down, drope-into, drops-above, drops-inside, drops-onto, drops-beneath, dropd, drops, drops-between, drop-in, drops-unto, drops-down, drops-at, drops-below, drops-against, drops-near, drops-of, drops-around, drops-for, drop-into, dropping-on, drops-spout, drops-behind, drops-without, drop-with, drops-beside, dropes-on, drops-up, dropped-on, drops-out, drops-over, drops-into, shedrops, drop-on, ccdrops-on, dropes-down, drops-fro, drops-along, dropping, dropped, drops-towards, shedrops-on, drops-underneath, drops-atop</p>

hold	holds-for, holds-around, holds-up, holds-into, holds-against, holds-beside, holds-by, hold-against, holds-between, holds-along, withholds, hold-in, holding, holds-to, holds-inside, holds-v, holds-down, holds-towards, holds-onto, holds, hold, holds-near, hold-on, holds-of, holds-at, holds-unto, holds-under, holds-over, hold-with, hold-up, holds-on, sheholds, holds-out, holds-from, holds-through, upholds, holding-with, holdswall-on, holding-in, holds-with, holds-in, holder, holds-atop, holds-w, hold-down, unholds-on, holder-with
touch	touches-along, touches-behind, touches-near, touched-with, touches-against, touches-on, touches-f.with, touches-beneath, shetouches-in, touches-before, touches-below, toucheses, touches-to, touch-on, touches-off, touches-across, touchers, touches-beside, toucheses#unsured-with, touches-round, shetouches-on, touches, touches-inside, touches-of, touched-on, touches-up, touches-around, toucher, touches-underneath, touching, touches-down, touches-from, touches-by, touches-under, touch-in, touched, touch, touches-into, touches-at, shetouches, touches-above, touches-in, touch-with, touches-over, touches-with
remove	removes-beside, remove-around, removes-from, removes-under, remove-to, removes-of, remove-in, removes-towards, sheremoves-in, removes-off, removes-to, removes-round, remove-with, removes-over, removed, removets, removes-at, remove, removes-with, removes-on, removes-around, removes-underneath, removes-in, removers, removes-like, removes-near, removes-among, removes-below, remove-under, remover-on, removes-down, remover, removes-fom, removes-by, remove-from, removes-up, removes-out, removes-inside, removes-into, removes-against, removes, removers-from, remove-on, removes-between, remover-from, removes-for, sheremoves, removes-onto, removes-beneath, removed-from, removes-behind, takes-out, take-off, take-out,takeout,pick-out,picks-out, unplug, unplugs-in, unplugs-from, unplugs-on, unplugs-with, unplug-from, unplugs, draws-out,disconnects-in, disconnect-with, disconnects-to, disconnect-from, disconnects-from, disconnects-on, disconnect, disconnects-with, disconnects
lift	lifts-by, lifts-toward, lift-off, lift-into, lifts-alongside, liftss-with, lifts-beneath, lifts-out, lifts-to, lift-from, lifts-with, lifts-off, lifts-towards, lift-in, lifted-on, liftes-with, lifts-into, lifts-on, uplifts, lifts, lifts-over, lifts-above, lifts-down, lifts-up, lifts-across, lifts-at, lifts-beside, lifts-onto, lifts-around, lifts-in, lifts-for, lift-up, lifts-under, lift, lift-on, lifts-of, lifts-from, lift-with, raise-in, raises-over, raised-with, raise, raises-toward, raises-above, raise-off, raises-at, raises-towards, raise-with, raises-up, raise-towards, raises-along, raises-beneath, raises, raises-for, raises-off, raises-with, raises-by, raised, raises-from, raises-of, raises-in, raises-on, raises-around, raises-underneath, raises-beside, raises-across, raises-down, raises-to, raise-to, puts-up
open	opens-wiith, opens-through, opens-up, opens-in, opens, opens-opposite, sheopens, opens-below, opening-with, opens-underneath, open-on, opening, opens-beneath, sheopens-with, opens-over, opens-by, opens-atop, opened-in, opens-for, open-up, openst, opens-forth, opens-at, opens-onto, opens-inside, opens-back, opens-outside, opens-with, opens-around, flips-open, opens-behind, opens-to, open, opened-with, opens-down, opens-on, opens-under, open-with, opens-after, open-beside, opened, opents, opens-beside, opens-along, opens-from, opens-near, opens-out, open-in, opens-into
pull	pull-in, pulls-for, pulls-past, pulls-back, pulls-down, pulls-with, pull-on, pulls-beside, pulls-by, pulls-on, pulls-through, pulls-in, pulled-beside, pulls-under, pulls-across, pullout, pulls-out, pulls-inside, pulls-up, pulling-from, shepulls, pulls-rom, pulls-around, pulls-towards, pulls-at, pulls-against, pulls-behind, pulls-near, pull-from, pulling-on, pulling-through, pulls-toward, pulls-wit, pulls-into, pull-with, pulls-after, pull-up, pull-out, pulls-from, pulls, pulls-over, pulls-along, pulls-to, pulls-outside, pull, pulls-beneath,pulls-out, pull-out, pulls-outside, pullout
turn	turned-to, turns-towards, turn-over, overturns-in, turns-up, turn, turns-inside, overturns, turns-toward, turning-inside, turns, turns-with, upturns, turned-on, turning-over, turns-underneath, turns-out, turns-onto, overturns-alongside, turning-in, turn-out, turn-at, turns-from, overturns-with, turn-with, turns-about, turns-at, overturn, turn-around, upturns-on, turns-behind, overturns-atop, turns-into, turns-back, upturns-in, sheturns, overturns-on, turning-on, turns-over, sheturns-around, turn-towards, turn-to, turns-above, turns-beside, turn-in, turns-down, turns-by, turned, turns-to, turns-around, turns-in, turns-under, overturn-from, turns-outside

press	presses-above, presses-the, pressing-onto, pushes-along, spress, presses, pushes-in, press-into, pushes-towards, pushes-at, pushes-out, pushes-up, press, pushes-on, compresses-on, presses-on, presses-for, pushes-round, compress-with, pushes-beside, pushes-behind, pushes-around, press-down, push, compresses-into, pushes, push-with, presses-to, pressed-into, pushes-beneath, press-with, compresses-with, pushes-over, compressor, presses-off, pushes-onto, push-up, pushes-outside, pushes-through, presses-under, push-out, pushing-out, pushed-into, push-to, pushes-underneath, pressure-up, presses-inside, push-on, pushers-in, pushes-under, pushes-inside, pushes-off, presses-from, pushes-from, presses-around, presses-by, presses-round, pushes-down, pushes-across, presses-against, pushes-by, pushes-past, presses-wit, pushes-toward, pushes-against, press-in, pushes-to, presses-atm, presses-in, presses-beside, presses-up, press-on, pushes-away, pushes-back, press-to, push-in, presses-down, presses-at, presses-like, pressing-with, presses-out, compresses-in, compresses, presses-onto, pushes-with, pushes-before, pressing, presses-into, compresses-inside, press-up, pushesb, presses-over, presses-with
turn-off	turn-off, turns-around, turns-down, turns-in, turns-of, turns-on, turns-to, turns-towards, switch-off, switched-off, switches-off
throw	throws-toward, throws-to, throw-up, throws-between, throw-down, throw-with, throws-across, throws-beneath, throws-towards, thrown-inside, throws-in, throwing-on, throws-up, throws-outside, throws-inside, throws-onto, throws-from, throw-on, throws-of, throw, thrown-to, throws-with, throws-by, throws-into, thrown-in, throws-under, throws-back, throws-off, throws-out, throws-over, throws-on, throws-down, throws-onto, throw-in, throws, throws-away, cthrows, throws-underneath, throw-into, shethrows, throw-from, throws-behind, throw-to, throws-through, throws-beside, throws-at
wash	cleanses, cleans-inside, clean-beneath, cleans-on, cleans-outside, cleanses-in, cleanses-with, clean-off, cleans-across, cleans-along, clean-in, cleanssink-with, cleans-at, cleaning, cleaning-on, cleans-over, cleanses-on, cleans-off, cleans-underneath, cleans-under, cleans-out, cleans-beneath, cleans-against, clean, cleans-near, cleans-to, cleans-in, cleans, cleans-back, cleans-from, cleans-with, cleans-by, cleans-beside, clean-with, cleans-around, cleansthe, cleaning-with, cleanses-with, cleans-below, cleans-towards, cleans-of, cleans-down, rinse-under, rinses-at, rinse-with, rinses-from, rinses-inside, rinses-on, rinses-underneath, rinses-under, rinse, rinses-over, rinses, rinses-with, rinses-through, rinses-off, rinses-in, rinse-in, sherinses-on, rinsed-in, rinses-out, rinses-of, rinses-into, washes-by, washes, washes-off, washing-with, wash, washed-with, washing-on, washes-in, washes-at, wash-with, washes-beside, washes-behind, washing-in, washes-through, washes-inside, washes-with, washes-under, washes-underneath, washed, washes-out, washes-on, washers-in, washes-into, washing, washed-inside, wash-in, washes-from
pour	pour-to, pours-across, pours-around, pours-with, pours-from, pours-inside, pouring-on, poured-on, pours-outside, pours-of, pours-over, pours-on, pours-off, pours-into, pour-in, pours-down, pour-from, pours-fro, pours-back, pours, pour-on, pours-in, pour-into, pours-to, pours-towards, pours-away, pours-out, pours-through, pour, pours-onto, pours-between, poured-into, pours-at, poured-in, pours-along,sieves-into,sieve-in, sieves-in
close	close, closes-back, close-on, closes-into, closes-near, closes-in, closes-from, closes-opposite, closes-onto, closed-with, close-up, closes-beneath, closes-at, closes, encloses-within, closes-with, encloses-with, closes-under, close-in, closes-on, closes-withy, closes-of, closes-atop, encloses, closes-beside, closes-up, closes-to, close-with, closes-behind, closes-through, closed, closes-above, closes-by
pat	hits-between, hits, hits-through, hits-inside, shits-in, hits-down, hits-onto, hits-against, hits-behind, hits-towards, hits-on, hits-to, hits-from, hits-around, hits-with, hits-beneath, shehits-against, hits-at, shits, hits-in, hits-into, hits-out, hit-in, hit-with, hits-beside, shits-from, hit, hitting-with, hits-under, hit-on, hits-over, hits-by, taps-from, untaps, taps-into, taps-to, taps-onto, tap-on, staps-with, taps-by, taps-against, taps, tap, taps-at, taps-on, taps-around, taps-beside, taps-with, taps-in

cut	cutes, cuts-beside, cut-into, cuts-of, cuts-wit, cuts-along, cutting-on, cutting-around, cuts-at, cuts-up, cutting-out, cuts-unto, cuts, cuts-outside, cuts-from, cut-in, cutting-into, cuts-into, cuts-through, cuts-out, cut-under, cuts-between, cuts-with, cut-with, cutting, cuts-around, cut, cuts-to, cuts-by, cuts-in, cut-out, cut-on, cut-off, cutting-with, cuts-without, cuts-on, cuts-under, cuts-across, cutback-with, cuts-off, cut-from, cuts-down, cutting, cuts-over, cute, cuts-inside, chopping, chops, chops-off, chopped-on, chop-with, chops-from, chops-with, chops-to, chops-over, chopped-from, chops-into, chops-in, chopping-on, chops-on, chops-at, chop, chopped, slices-in, slices-by, slices-to, slices-with, slice, slices-through, slices-from, slices-onto, slices-on, slices-inside, slices-into, slices-off, slices, trim, trimming-down, trims-on, trims, trims-off, trims-to, trims-in, trims-with, trims-into, trims-around, trims-out, trims-from, trims-at, trim-with
carry	carried, carries-wiith, carries-unto, carries-beside, carriy, carries-on, carrirs, carries-down, carries, carries-with, carriers-up, carries-underneath, carriers-with, carries-under, carries-into, carries-off, carries, carries-by, carries-at, carries-through, carries-outside, carrying-from, carriers, carries-around, carries-up, carried-on, carrying, carriers-from, carries-towards, carry-in, carries-in, carries-over, carries-to, carries-between, carries-out, carrues, carries-of, carry, carries-along, carries-from, carries-across, carried-from, carryy
clear	wipes-across, wipes-in, wipes-off, shewipes-in, wipes-up, wiped-on, wipes-beneath, wipes-by, wipes-inside, wipes-around, wipes-into, wipes-of, wiped-with, wipe, wipe-off, wipes-as, wipes-at, wipes-out, wipes-from, wipes-with, wipes-under, wipes-behind, wipes-over, wipes-against, wipes-underneath, wipes, wipe-in, wipes-down, wipes-onto, wipes-on, wipes-to, wipe-with, clears-with, clear-in, clears-inside, clears, clears-from, clearing, clears-by, clears-on, clears-under, clears-beside, clears-in, clears-of, clears-before, clears-around, clears-to, clear, clear-with, clearing-with, clears-out, clears-off
rub	rubs-off, rubs-through, rubs-into, rubs-onto, rubs-in, rub, rub-between, rubs-alongside, rub-against, rubs-over, rubs-v, rubbed-on, rubs-aganist, rubs-under, rub-with, rubs-above, grubs-from, rubs-from, rubes-on, rubs-up, rubbing-with, rubs-across, rubs-at, rubs-of, rubs-against, rubs-inside, rubs-between, rubs-with, grubs-with, rubs-before, rubs-by, rubs, rub-on, grubs, rubbing, rubs-on, rubs-to, rubs-around, rubbing-on, scratches-off, scratches-in, scratches-by, scratches-behind, scratches-from, scratches-to, scratchers, scratches-on, scratches-between, scratch, scratchs, scratches-with, scratchs-with, scratches, scratch-with, scratch-off
fold	fold-into, folding, folds-under, folds-over, folds-on, folds-into, folds-down, folds-onto, refolds, folds-off, folds-with, folds-out, folds-above, ufolds, fold, folds-across, folds, folds-to, folds-back, folds-inside, fold-with, folds-from, folds-up, folds-at, folds-against, folds-around
gather	gathered-on, gathers-into, gathers-to, gathers-near, gather-with, gathers-around, gather-on, gathers-behind, gathers-on, gathers-inside, gathers-round, gathers-with, gather-in, gathers-under, gathers-over, gather, gathers-in, gathered-with, gathers-onto, gathers-from, gathers-up, gathers-out, gathers, collect-with, collect, collects-by, collects-inside, collect-from, collects-from, collects, collects-into, collects-with, collects-in, recollects, collects-to, collects-on
stretch	stretches-around, stretches-into, stretches-towards, stretch-out, stretches-to, stretches-with, stretches-down, shestretches, stretches-in, stretchers, stretches-from, stretchers-outside, stretches-across, stretches-before, stretches, stretchs, stretches-out, stretches-above, stretches-under, stretches-along, stretches-for, stretches-up, stretch-with, stretchers-towards, stretches-over, stretch, stretches-on, stretches-outside, stretches-at, stretches-toward, stretches-past

attach	attaches-onto, reattaches, attaching-to, attaches-into, attaches-under, attach, attaches-against, attaches-to, attaches-from, attaches-with, reattaches-to, attaches-underneath, attach-on, attaching-in, attaches-in, reattaches-on, attach-to, attaches, attaches-on, attaches-by, reattaches-in,connects-in, connect-with, connects-from, connects-into, connects-to, connect-to, connects, connects-through, connect-from, connected-on, connects-with, connects-on, connect, inserts-into, insert-in, inserts-at, inserts-to, insert-with, inserts-inside, inserts-under, inserts-back, reinserts-to, inserts-by, inserting-into, inserts-between, insert-on, reinserts, inserts-in, inserts-through, inserts-beneath, inserted-to, inserts-below, inserts-with, inserts-against, inserts-on, insert-into, inserts, insert, inserted-in, inserts-from, inserts-onto, inserts-near, reinserts-into, inserts-around, plugs-into, plug-in,plugs-inside,plugs-in,pushes-in,pushed-into,pushers-in,pushes-inside,push-in,pushes-into
flip	flips-by, flips-onto, flips-from, flips-inside, flips-off, flips-back, flips-on, flip-on, flips-over, flips-with, flips, flips-in, flips-between, flips-amongst, flips-out, flips-through, flips-open, flips-at, flip-in, flipping-on, flip, flips-towards, flips-forward, flips-up, flips-around, flips-down, flips-into, flipping, flips-to,turn-over,turning-over,turns-over
turn-on	turn-on,turned-on,turns-on,turning-on,switches-on,switch-on
scoop	scoops-up, scoops, scoopes-with, scoops-onto, scoops-on, scoops-by, scoops-from, scoop-in, scoops-into, scoops-with, scoops-off, scooped-with, scoop-into, scoop-with, scoops-inside, scoops-in, scoop-out, scoops-to, scoop-from, scoops-out, scoop, scoops-wit
shake	shake-off, shake, shakes-with, shakes-over, shakes-between, shakes-in, ashaker, shakes-out, shakes-above, shakes-by, shakes-under, shakes-into, shakes, shakes-of, shakes-off, shake-with, shakes-inside, shakes-from, shake-in, shakes-on, shakes-at, shakes-around
bend	bends-beside, bends-up, bends-down, bends, bends-at, unbends, bends-near, bends-in, bends-to, bends-towards, bends-against, bends-toward, bends-by, bends-over, bends-around, bends-into, bends-beneath, bends-behind, bends-on, bends-out, bends-along, bends-forward, bend-towards, bends-under, bends-with
dip	dips-from, dips-into, dips-onto, dip-into, dips-with, dipped, dips-inside, dips-in, dips-beside, dips-beneath, dips-on, dipping-in, dip-in, dips, dips-under, dips-to, dips-through, shedips-in
roll	rolls-across, rolles, rolls-in, rolls-round, rolled, rolling, roll-out, rolls-under, rolls-inside, roll, rolls-on, rolls-through, strolls-on, strolls, rolls-against, rolls-around, rolls-onto, roller-in, rolls-down, rolls-back, rolls-up, rolls-off, rolls-of, rolls, rollys-on, roll-with, rolled-into, rolls-to, rolls-between, srrolls-on, rolls-out, rolls-over, roll-on, rollers, rolls-with, rolls-towards, rolls-into, rolls-from, rolling-into
wrap	wraps, wrapps, wraps-from, wraps-in, rewraps-around, wraps-around, wrapping-around, wrap, wrapper, wrap-on, wraps-up, wraps-on, wraps-inside, wraps-round, wraps-at, wraps-over, wrapped-on, wraps-with, covers-up, coverses-with, covers, covers-back, covers-of, coverers-with, covers-by, covers-on, cover-in, cover-with, covers-in, covers-down, recovers, cover, covers-from, covers-with, rolls-up
lower	lowers-with, lowers-from, lowers-underneath, flower-from, lowers-to, lowers-over, lowers-unto, lowers, lowers-onto, lowers-into, lowers-above, lowers-towards, lowers-along, lowers-down, lowers-in, lowers-toward, lowers-by, lower-from, lowers-under, lowers-on
drink	drinks, drinking, drinks-out, drink-from, drinks-in, drinks-on, drinking-from, drinks-from, drink, drinks-with, drinks-up, drink-on
spread	spreads-inside, spreads-around, spreads-from, spreads-in, spread-in, spreads-to, spreads-out, spreads-at, spreads-into, spreads-on, spreads-down, spread, spreads-with, spread-with, spreads-up, spreads-under, spreads-beside, spread-from, spread-out, spread-around, spreads-over, spreads-by, spreads-onto, spreads, spreading-on, spread-on, spreads-towards, spreads-across
drag	drags-down, drags, drag, drags-with, drag-in, drags-on, drags-into, drags-inside, drags-along, drag-with, drags-from, drags-in, drags-around, drags-to, drags-across, drags-off, drags-out, drags-towards, drags-beneath, drags-through, drags-up

mix	mixes-from, mixing, mixing-on, mixes-inside, mixes-into, mixes-in, mix, mix-with, mixes-with, mixed-with, mixes-on, mixes-up, mixing-with, mixex-with, mixes-by, mixes, stirs-inside, stirring-with, stirrs, stirson, stirs, stirs-from, stirs-into, stir-with, stirring-in, stirred-in, stirs-with, stirs-in, stir-on, stir-in, stirring-on, stirring, stirring-inside, stir, stirred-with, stir-into, stirs-around, stirs-up, stirs-at, whisks-on, whisks-in, whisks-with, whisks,scrambles-in, scrambles, scrambles-for, scrambles-with,folds-in,fold-in
wear	wears-for, wears-before, wear, wears-in, wears, wears-under, wear-in, wears-around, wears-to, wears-from, wears-v, wears-onto, wears-with, wears-back, wears-on, wears-beneath, wears-by, wear-on
divide	separate-with, separates-in, separates-with, separates-over, separates-on, separate, separates-into, separates-from, separated-with, separates-to, separates, separated-from, separate-from, separate-for, detaches-on, detaches-rom, detaches-with, detach, detaches-off, detaches-from, detaches-into, detach-from, detaches-in, detached, detaches-back, detaches, detaches-behind, detaches-at, splits-with, splits-into, splits-from, splits-on, splits-to, split-with, splits-in, splits, splits-by, splits-inside
eat	eats, eats-from,eats-at,eat,eats-off,eats-with,eats-in,eats-on,eats-out,bites-in, bites, bite, bites-with, bites-from
bring	brings-under, brings-up, brings-on, brings-in, bring-out, brings-from, bring-from, brings-down, brings-towards, brings-out, bring-on, brings, brings-to, brings-with
hang	hangs-by, hangs-with, hang-on, hangs-to, hangs-onto, hangs-from, hangs-over, hangs-at, hangs-back, hangs, hangs-up, hangs-beside, hangs-inside, hanged, hang, hangs-on, hangers-on, hangs-in, hang-in, hangs-against, hanging, hangers
read	reads-back,read,reads-at,reads-with,reads-through,reads-out,reads,read-on,reads-in,reads-to,reads-on,reading,reads-from,reads-to
scrape	scrapes-from, scrapes-round, scrapes-into, scrapes-inside, scrapes-on, scrapes-beside, scrapes-out, scrapes-against, scrapes, scrapes-underneath, scrapes-at, scrape-on, scrape, scrapes-through, scraped, scrape-in, scrapes-in, scrapes-beneath, scraped-on, scrapes-off, scrapes-with, scraped-in, scrapes-onto, scraper-with, scrapes-of, scrape-from, scraped-inside, scrapes-to
brush	brush-on, brushes-from, brushes-over, brush-with, brushes-against, brushes-onto, brush, brushes-into, brushes, brushes-on, brushes-through, brushes-across, brush-through, brushes-with, brushes-to, brushes-off, brushes-under, brushes-in,sweeps-out, sweeps-back, sweeps-off, sweeps-into, sweeping, sweeps-of, sweeps-wit, sweeps-towards, sweeps-inside, sweeps-on, sweeps-onto, sweeps-along, sweeps-under, sweeps-with, sweeps-from, sweeps-behind, sweep-on, sweeps-to, sweeping-outside, sweeps-outside, sweeps-in, sweeps, sweep-into, sweep-with, sweeps-down, sweeps-around, sweeps-across, sweeping-with, sweep
screw	tightens-under, tightens-in, tightens-into, tightens-from, tightens-to, tightens, tighten-at, tighten, tightens-at, untightens, tightens-on, tightens-with, untightening, tightening, tightening-with, tightens-against, tighten-with, tighten-to, tighten-on, tightens-behind, tightens-around, tightens-up, tightens-underneath, screws-up, screw-from, screw, screws-on, screws-out, screws-at, screws-with, screw-through, screws-back, screws-under, screws-into, screws-to, screws-through, screw-into, screwing-with, screw-with, screw-on, screws-beneath, screw-in, screws-onto, screws-inside, screws-in, screws, screwed-to
squeeze	squeezes-through, squeezes-from, squeezes-against, squeeze-with, squeeze, squeezed-out, squeezes-up, squeezes-between, shesqueezes-with, squeezes-to, squeezes, squeezes-inside, squeezes-on, squeezes-onto, squeeze-in, squeeze-on, squeezes-into, squeezes-with, squeezes-over, squeezes-out, squeezes-in, squeezes-around, squeezes-under
scrubs	scrub, scrubs-off, scrubs-in, scrubs-with, scrubs-by, scrubs-on, scrubbing-with, scrubs-beside, scrubs-from, scrubs-under, scrubs-into, scrub-with, scrubs-inside, scrubs-of, scrubs, scrubs-beneath, scrubs-out
unroll	unfolds-in, unfolds-to, unfolds, unfolding, unfolding-with, unfolds-on, unfold, unfolds-from, unfolds-with, unfolds-around,unrolls-in, unrolls-with, unrolls-on, unrolls, unrolls-from

give	gives-on, give-in, gives-from, gives-in, gives-with, give-to, gives-back, gives-up, give-with, gives, gives-to, give, gives-through, gives-out, gives-w, gives-towards
draw	draws-back, draws, draws-across, draw-across, draws-around, draws-on, draws-near, draws-down, draws-in, draws-by, drawing-on, draw, draws-through, draw-on, draws-out, draws-from, draws-along, drawing, draws-as, draws-up, draws-above, draws-at
loosen	loosens-by, loosen-on, loosen, loosens-from, loosens-against, loosening-with, loosens-round, loosens-behind, loosens-around, unloosens, loosens-at, loosening-on, loosen-with, loosens-into, loosens-out, unloosens-from, loosens, loosens-up, loosens-under, loosens-on, loosens-in, loosens-with
break	breaks-up, break-on, break-with, breaks-of, breaks-at, breaks, breaks-unto, break, breaks-on, break-off, breaks-in, breaks-down, break-apart, breaks-for, breaks-into, breaks-off, breaks-by, breaks-from, breaks, breaks-with, breaks-out
peel	peeling, peels-into, peel, peels-with, peels-from, peel-out, peels-of, peels-over, peeling-from, peels-on, peels-under, peels-out, peels-in, peels, peels-off, peels-onto, peels-around
paint	painting-by, paint-from, paints-opposite, paints-to, painting-in, paints-around, paints-in, paints-onto, painting-above, paint-with, paint-inside, paint-to, painting-near, paints-from, paint, paint-on, paints-beside, paints-beneath, paint-in, painted-with, paints-inside, paints-before, paints-on, painting-around, paints, paints-at, paints-with, painting, paints-over, painting-with, paintboard, paints-by, paints-near, paintss-on, paints-above, paint-down, painting-on
rip	tears-on, tear-on, tears-in, tears-by, tears-apart, tears-under, tears-off, tears-into, tears-up, tears, tears-around, tears-with, intearacts-with, tears-inside, tears-from, tears-out,rips-in, ripping, trips-with, rippes-with, rips-off, rips-with, rips-into, rips
sprinkle	sprinklers, sprinklers-on, sprinkles-from, sprinkles-into, sprinkle-on, sprinkles-in, sprinkles, sprinkles-with, sprinkle-inside, sprinkles-to, sprinkle, sprinkle-into, sprinkles-on, sprinkle-from, sprinkles-before, sprinkles-onto, sprinkles-beside, sprinkles-over
drill	drilling-with, drill-with, drills-around, drills-onto, drills-into, drilling-on, drills-to, drilling-through, drills, drills-inside, drills-out, drilling, drills-under, drill-on, drill-to, drills-with, drills-through, drill, drills-across, drills-up, drill-into, drills-in, drills-on, drills-by, drill-in, drill-from, drilled
unwrap	unwraps-on, unwraps, unwraps-around, unwraps-over, unwraps-from, unwraps-with, unwraps-in, unwrap

Table 6: ARGOIM action classes and their corresponding open-vocabulary verbs.

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