Abstract Concepts and Inner Speech: A Dual-Task Interference Study

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Abstract

Do we need inner speech to understand and process abstract concepts? In two preregistered experiments, we tested these questions using dual-task interference in an odd-one-out paradigm where participants were asked to decide either which image did not represent the same concept as two other images (Experiment 1) or which word was not a synonym for the same concept as two other words (Experiment 2). In Experiment 1, there were large differences in both reaction time and accuracy between concrete and abstract concepts. When abstract concepts were represented through images, visuospatial interference had a detrimental effect on reaction time, but verbal interference did not. When the same abstract concepts were represented through words (Experiment 2), there were facilitatory effects of both interference types. We discuss possible interpretations of these findings in terms of visual and verbal access to abstract concepts and the hypothesized role of inner speech in processing abstract concepts.

Keywords: abstract concepts; abstract words; abstractness; concrete concepts; interference; dual-task; inner speech

Introduction

A fundamental human ability consists in forming and using abstract concepts and the words expressing them, such as "comfort", "destruction", and "certainty". Although they are not opposed to concrete concepts (e.g., "bottle", "pile") in a dichotomous way, abstract concepts differ from them along many dimensions (see Borghi, 2022, for the various dimensions). Among the most crucial differences, abstract concepts evoke sensorimotor experiences less and elicit interoceptive and affective experiences more than concrete concepts (Connell et al., 2019; Vigliocco et al., 2014). In addition, the exemplars of abstract concepts have less in common and are more heterogeneous (Lupyan & Mirman, 2013; Langland-Hassan et al., 2019).

Importantly, different varieties of abstract concepts exist (review in Conca et al., 2021; see also Harpaintner, 2018; Muraki et al., 2022). In this study, we will use words belonging to four kinds, i.e., philosophical-spiritual concepts (from now *philosophical* for short) (e.g., "belief", "spell"), emotional-inner state ones (from now *emotional* for short) (e.g., "fear"), physical-spatiotemporal and quantity words (from now *physical* for short) (e.g., "space," "acceleration"), and self-sociality words (from now *social* for short) (e.g., "menace", "seduction"). These four kinds were identified with a cluster analysis based on ratings on 15 dimensions of 425 Italian abstract words (Villani et al., 2019). The four kinds of concepts differ in the dimensions that characterized them. Thus, philosophical concepts were the most abstract, while physical ones evoked more sensorimotor experience; social concepts activated both inner and sensorimotor experiences more than the others, and emotional concepts more inner experiences. Because of the heterogeneous nature of abstract concepts, recent views proposed that linguistic and social experience is particularly paramount for their acquisition, representation, and use (Borghi et al., 2019; Dove, 2022; Pexman et al., 2023).

Language and Abstractness

The present study focuses on language's role in abstract concepts and their subkinds. Language might be critical both during the acquisition and use of abstract words. During conceptual acquisition, linguistic labels can increase the similarity of dissimilar exemplars (Borghi et al., 2019; Lupyan et al., 2020), and verbal explanations from other people can help us detect similarities among exemplars and form novel categories. During the processing and use of abstract concepts, we often feel uncertain and not very confident in our knowledge of their meaning (Mazzuca et al., 2022). Hence, we might need others to ask them for information, negotiate the word's meaning or ask which meaning they have in mind (Borghi, 2022; Mazzuca & Santarelli, 2022). Linguistic exchanges can thus be crucial to refining and redefining abstract words' meaning. In this process, we might use inner speech to search for possible meanings or to prepare ourselves to ask for information or negotiate it with others (Borghi & Fernyhough, 2023).

Notably, the importance of language might be more marked with increases in abstractness; hence some kinds of abstract concepts might be more language-dependent than others. Specifically, philosophical concepts, whose meaning

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is less determinate and possibly more negotiable and open, might benefit more from linguistic labels, explanations, and exchanges than other abstract concepts.

Dual-Task Interference

How can we test the involvement and role of language in abstract compared to concrete concepts and investigate potential differences among subkinds of abstract concepts? More than a role of language in general, we hypothesize a specific role for inner speech. With more abstract words, like philosophical ones, inner speech might help to inner search and eventually re-explain the word's meaning, to prepare to revert to other people to ask them for information, understand their viewpoint, or discuss with them the word's meaning. A good way consists in using tasks that interfere with people's ability to use inner speech to process abstract concepts using a dual-task paradigm (Nedergaard et al., 2022). Interference tasks have many benefits for research on cognition, as they allow researchers to test for the functional relevance of a given process (Ostarek & Bottini, 2021). Previous dual-task evidence shows that articulatory suppression (continuously repeating a syllable) hinders the categorization of abstract concepts to a larger extent than it affects concrete concepts and to a larger extent than non-articulatory motor interference, a ball-squeezing task (Fini et al., 2021). Articulatory suppression is widely employed to test for the use of inner speech (Nedergaard et al., 2022). However, we wanted to use an implicit paradigm in which participants had to keep verbal vs. visual information in mind without overtly repeating or rehearsing it. This was primarily because the experiments were conducted online where articulatory suppression is difficult to control and assess. We therefore designed a dual-task experiment where trials involving the processing of abstract and concrete concepts were interleaved with trials designed to interfere with either visuospatial or verbal processes.

Hypotheses

We advanced three main hypotheses, preregistered on the Open Science Framework. See https://osf.io/9g67d/.

1. We predicted **slower reaction time and lower accuracy** with **verbal interference** compared with visual interference and control with abstract compared with concrete concepts.
2. We predicted that there would be differences in how the categories of abstract concepts (i.e., philosophical, physical, emotional, and social concepts) are affected by verbal interference.
3. We predicted **faster reaction time and higher accuracy** in the **concrete concepts** condition compared with the abstract concepts condition, thus extending results on the concreteness effect (Paivio et al., 1994).

Method

Experiment 1: Picture Stimuli

Participants We recruited 124 participants from the online platform Prolific (median age = 28; range = 19-67). See preregistration for sample size justification. Participants were required to be fluent speakers of Italian and have Italian as their first language. Participants were paid £2.5 (median time spent: 23 minutes and 46 seconds). We subsequently excluded eight participants because they performed below chance on the odd-one-out trials in at least one condition (7) or because they only had data for the abstract condition (1). This left us with 116 participants in Experiment 1.

Stimulus Selection We selected 80 abstract concepts (20 from each of the emotional, social, philosophical, and physical categories of abstract concepts) from the Villani et al. (2019) data set and 40 concrete concepts (20 scoring high on concreteness and 20 scoring lower on concreteness) from the Della Rosa et al. (2010) data set.

For each concept, we found two images that represented the concept from copyright-free databases on the internet (e.g., Pixabay, Unsplash). The images were validated in two ways: First, we showed a sample of participants the first images we had selected and asked them to provide labels for them as well as to rate their "visual complexity". We then excluded the ones where all the top three labels participants gave were more than two standard deviations away from the mean semantic distance between target and provided label. Semantic distance was operationalized as cosine distance retrieved from the 'snaut' database (Marelli, 2017; Mandera, Keuleers, & Brysbaert, 2017). This was also the case for other measures of semantic distance discussed throughout the present study. Seven concepts were completely replaced and substituted for different ones from the same categories, and 54 images were replaced because they did not evoke the intended concept. Second, we showed another set of participants all the images used along with their intended word (e.g., the image for "beauty" along with the word "beauty") and asked them how well the word and image fit together (from 0 to 100).

Procedure Participants saw three images at a time, two representing the same concept (e.g., two different images representing "anger") and one image representing another concept (e.g., "uncertainty"). Their task was to decide which image was the odd one out as quickly and accurately as possible. There were three conditions in the experiment: a verbal interference condition, a visuospatial interference condition, and a control condition with no interference. In the verbal interference condition, participants had to solve 1-back matching problems of auditorily presented nonsense words interleaved with the odd-one-out trials. In 1-back matching problems, participants have to determine whether or not a given stimulus is identical to the stimulus presented one trial earlier. In the visuospatial interference condition, participants had to solve 1-back matching problems of visually presented polygon shapes interleaved with the odd-one-out trials. See Figure 1.

Experiment 2: Word Stimuli

Participants We recruited 116 participants from the online platform Prolific (median age = 26; range = 20-62). See preregistration for sample size justification. Participants were required to be fluent speakers of Italian and have Italian as their first language. Participants were paid £2.5 (median time spent: 12 minutes and 40 seconds). We excluded participants who had participated in Experiment 1 and in the image validation tasks.

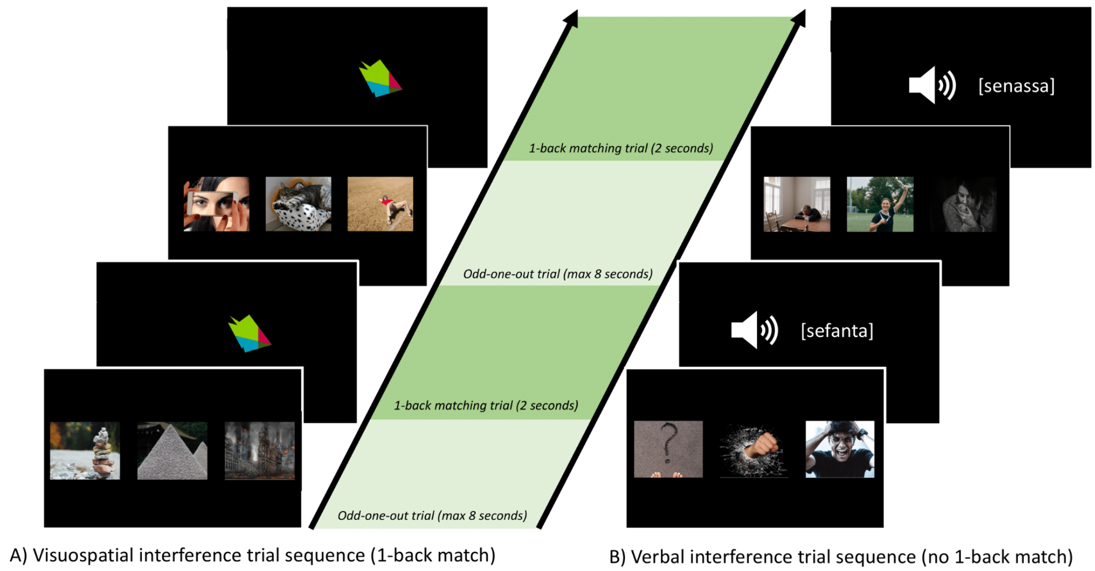

Figure 1: Experiment procedure for Experiment 1. Figure 1A shows a trial sequence in the visuospatial interference condition (first trial: "heap" and "destruction"; second trial: "image" and "idleness"), and Figure 2B shows a trial sequence in the verbal interference condition (first trial: "uncertainty" and "wrath"; second trial: "uneasiness" and "enthusiasm").

Stimulus selection Experiment 2 used the same abstract concepts as in Experiment 1. We selected one synonym for each word (parallel to two images for each concept in Experiment 1) by picking synonyms among each word's closest semantic associates and having the list of synonyms validated by four native speakers of Italian who were not working on the study.

Procedure On each trial, participants saw two related concepts (synonyms) and one unrelated concept (the odd-one-out). Aside from the switch from picture stimuli to word stimuli, the experimental setup was the same. We did not include a concrete condition.

Results

Experiment 1: Picture Stimuli

We excluded nine abstract concepts because participants performed below chance at them ("area", "competition", "growth", "justice", "indifference", "innocence", "uneasiness", "torment", and "beauty"). On all plots, colored dots show individual participant means, and error bars indicate 95 % confidence intervals.

Descriptive Statistics See Table 1 and Figures 2 and 3.

Table 1: Reaction time and accuracy with 95 % confidence intervals as a function of abstractness condition and interference condition in Experiment 1.

Condition	Reaction Time (M)	Reaction Time (95 % CI)	Accuracy (M)	Accuracy (95 % CI)
Abstract (*control*)	2404 ms	±49 ms	0.78	±0.02
Abstract (*verbal*)	2446 ms	±54 ms	0.76	±0.02
Abstract (*visual*)	2651 ms	±58 ms	0.79	±0.02
Concrete (*control*)	1596 ms	±41 ms	0.95	±0.01
Concrete (*verbal*)	1519 ms	±42 ms	0.96	±0.01
Concrete (*visual*)	1530 ms	±36 ms	0.95	±0.01

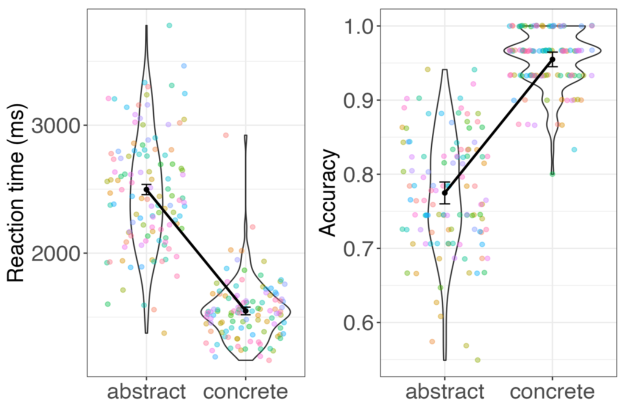

Figure 2: Reaction time and accuracy in Experiment 1.

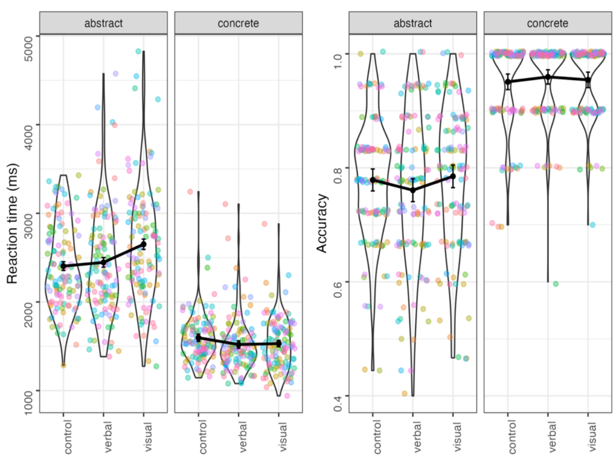

Figure 3: Reaction time and accuracy by interference condition in Experiment 1.

Abstractness Level and Interference Condition Predicting Reaction Time We conducted a generalized linear mixed model of abstraction level and interference condition predicting reaction time modeled as a Gamma distribution. This model included random intercepts for participant, item, and condition order. Concrete trials were faster than abstract trials (β= -0.53; SE = 0.05; t = -10.76; p < .001), and both verbal and control interference were faster than visuospatial interference (control: β = -0.03; SE = 0.01; t = -2.48; p = .013; verbal: β = -0.03; SE = 0.01; t = -2.53; p = .011). There was also an interaction effect between abstractness/concreteness and interference which diminished the difference between abstract and concrete in the control interference condition (β = 0.08; SE = 0.02; t = 3.75; p < .001).

Abstraction Level and Interference Condition Predicting Accuracy We conducted a generalized linear mixed model of abstraction level and interference condition predicting accuracy. This model included random intercepts for participant and target item. Concrete trials were more likely to be correct than abstract trials (β = 2.2; SE = 0.32; t = 6.78; p < .001), and verbal interference trials were less likely to be correct than visuospatial interference trials (β = -0.25; SE = 0.09; t = -2.82; p = .005). There were no significant interaction effects.

Categories of Abstract Concepts We conducted a generalized linear mixed model of abstract category level (social, emotional, physical, and philosophical) and interference condition predicting reaction time modeled as a Gamma distribution. This model excluded concrete concepts trials and included random intercepts for participant, item, and condition order. It corroborated the results that both verbal and control interference were faster than visuospatial interference. There were no significant effects of abstract category and no significant interaction effects.

We conducted a generalized linear mixed model of abstract category level and interference condition predicting accuracy. This model excluded concrete concepts trials and included random intercepts for participant, item, and condition order. It corroborated the result that verbal interference was associated with lower accuracy. There was also a significant interaction effect between the control condition and the physical category – on physical category trials in the control condition, participants were even less likely to be correct (β = -0.35; SE = 0.17; t = -2.05; p = .04). See also Figure 4.

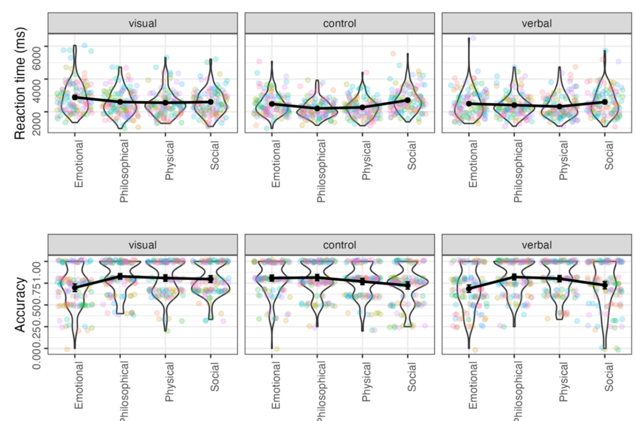

Figure 4: Reaction time and accuracy by abstract concept category and interference condition in Experiment 1.

Semantic Distance Between Target Word and Distractor Word To test that participants were actually processing the underlying concepts and not just making their judgments based on surface details of the images, we conducted two models of the cosine distance between target and distractor as a predictor of accuracy and reaction time. The larger the distance, the more likely participants were to be correct (β = 1.94; SE = 0.40; z = 4.88; p < .001), and the faster they were (β = -0.49; SE = 0.07; t = -7.12; p < .001).

Experiment 2: Word Stimuli

Descriptive Statistics See Table 2 and Figure 5.

Table 2: Reaction time and accuracy with 95 % confidence intervals as a function of interference condition in Experiment 2.

Condition	Reaction Time (M)	Reaction Time (95 % CI)	Accuracy (M)	Accuracy (95 % CI)
Control	2721 ms	±39 ms	0.89	±0.01
Verbal	2578 ms	±38 ms	0.90	±0.01
Visual	2611 ms	±36 ms	0.91	±0.01

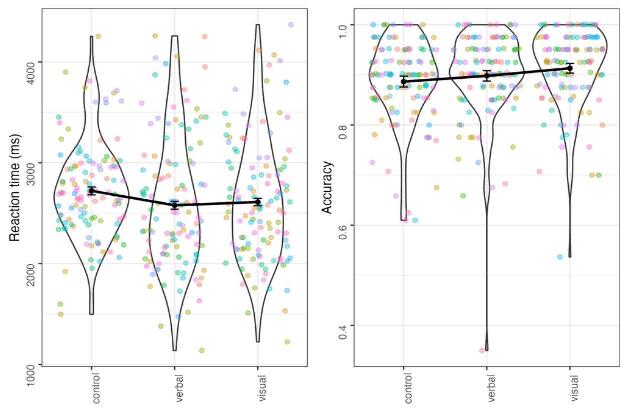

Figure 5: Reaction time and accuracy as a function of interference condition in Experiment 2.

Interference Condition Predicting Reaction Time and Accuracy A generalized linear mixed model of interference condition predicting reaction time modeled as a Gamma distribution indicated that the control condition was significantly slower than the overall average ($\beta = 0.05$; SE = 0.01; t = 10.46; $p < .001$), and that the verbal interference condition was significantly faster ($\beta = -0.03$; SE = 0.01; t = -6.83; $p < .001$). The model included random intercepts for participant and target word. A binomial generalized linear mixed model with the same random effects structure indicated that the control condition was also associated with lower accuracy compared with the overall mean ($\beta = -0.16$; SE = 0.04; t = -3.95; p = .001).

Categories of Abstract Concepts A generalized linear mixed model with category predicting reaction time modeled as a Gamma distribution (including participant and target word as random intercepts) indicated that the philosophical category was significantly slower than the grand mean ($\beta = 0.06$; SE = 0.02; t = 3.11; p = .002), and the physical category was significantly faster ($\beta = -0.05$; SE = 0.02; t = -2.62; p = .009). There was a significant interaction between the physical category and verbal interference where the reaction time for this category was even faster in this condition compared with the grand mean ($\beta = -0.02$; SE = 0.01; t = -2.7; p = .007).

A generalized linear mixed model predicting accuracy and including participant and target word as random intercepts indicated that the philosophical category was more difficult than overall mean accuracy ($\beta = -0.53$; SE = 0.15; t = -3.55; $p < .001$), and that the physical category was easier than overall mean accuracy ($\beta = 0.38$; SE = 0.15; t = 2.51; p = .012). There were no significant interaction effects. See Figure 6.

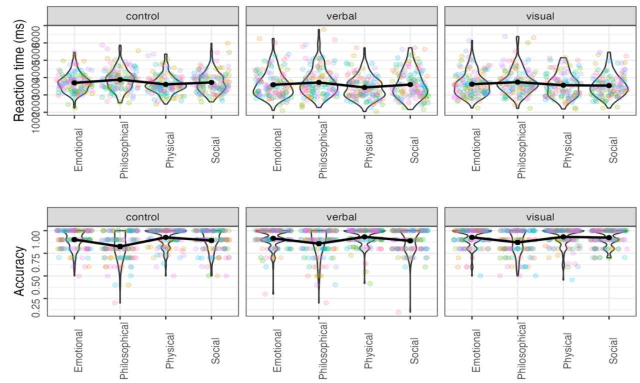

Figure 6: Reaction time and accuracy by abstract concept category and interference condition in Experiment 2.

Semantic Distance Between Target Word and Distractor Word As in Experiment 1, we explored whether participants were processing the underlying concepts by testing the effect of the cosine distance between target concept and distractor concept. A larger distance was associated with both higher accuracy ($\beta = 4.99$; SE = 0.56; t = 8.89; $p < .001$) and faster reaction times ($\beta = -0.54$; SE = 0.06; t = -8.40; $p < .001$).

Discussion

In two experiments, we tested the effects of verbal and visuospatial interference tasks on odd-one-out problems involving abstract and concrete concepts. As predicted, problems involving concrete concepts were easier than problems involving abstract concepts, and verbal interference was associated with reduced accuracy on problems involving abstract concepts compared with visuospatial interference and control (in Experiment 1). We did not see any differences between our four different categories of concepts in how they were affected by interference.

Abstract versus Concrete Concepts

In Experiment 1, we saw very clear differences between trials involving abstract concepts and trials involving concrete concepts. Participants detected the odd one out both more quickly and more accurately for problems involving concrete concepts. There are multiple potential explanations for this. First, it could be the case that the pictures of concrete concepts had overall lower visual complexity than the pictures of abstract concepts. We do not believe this explanation is likely given that we tested the rated “visual complexity” of the images as part of the image validation, and this visual complexity predicted accuracy and response time only on problems involving concrete concepts. Second, the difference between abstract and concrete trials could involve the higher imageability of the concrete concepts – that the association between image and concept is more straightforward and less multifaceted for concrete concepts than for abstract concepts. This seems plausible given the connection between concreteness, imageability, and context availability in previous literature (Paivio, 1994; Schwanenflugel et al., 1992; see also Villani et al., 2019, for an Italian stimuli sample). To further explore these potential explanations, we tested whether imageability, concreteness, and context availability predicted accuracy and response time while only looking at trials involving abstract concepts. Only context availability – how easily people can think of an imagined situation or circumstance for a word (Altarriba, Bauer, & Benvenuto, 1999; Schwanenflugel et al., 1992; Davis et al., 2020) – appeared to be clearly associated with faster response times and better accuracy. We believe our results contribute interesting perspectives on context availability as a metric; in addition to a measure of how easy it is to imagine situations involving a specific concept, it would be useful to add a measure of how variable these imagined situations are. It is likely that asking someone to come up with situations involving "carrot" will result in more similar situations than asking someone to come up with situations involving "uncertainty". There are many potential instantiations of abstract concepts and only a few – but more readily available – of concrete concepts. Likewise, there is not much competition among labels for an image of an "egg" whereas an image of "poverty" might also depict "sadness" or "loneliness".

Effects of Visuospatial and Verbal Interference

Our predictions regarding visuospatial and verbal interference were only partially confirmed. In Experiment 1, trials with visuospatial interference were slower than verbal interference trials, but they were not less accurate. On the contrary, trials with verbal interference were both faster and less accurate than visuospatial interference trials. First, this is interesting as it indicates that visual access to the underlying concept was slowed down but ultimately accurate in the visuospatial interference condition. Second, visual processing appeared unimpaired in the verbal interference condition but perhaps less precise in labeling the underlying concepts or keeping them in mind for comparison which would be necessary for detecting the odd one out. In Experiment 2, which used word stimuli instead of images, there were no interference effects. In fact, the control condition was associated with both poorer accuracy and slower response times.

It is possible that the odd-one-out task was simply too easy in Experiment 2 so that participants were able to solve the problems without interference from the simultaneous 1-back matching. Future studies should use more disruptive interference tasks, such as articulatory suppression. Our choice of interference task was primarily motivated by the difficulties involved in monitoring articulatory suppression when study participation takes place online.

Different Categories of Abstract Concepts

We further hypothesized that there would be differences in how categories of abstract concepts were affected by interference. We did not find significant interference differences, possibly because the interference tasks were not sufficiently disruptive. However, and interestingly, the categories we included in these two experiments – philosophical, emotional, physical, and social concepts – did not show the same patterns across the two experiments. When the abstract concepts were represented through images (Experiment 1), there were no differences between the categories either for response time or accuracy. However, when abstract concepts were represented through words (Experiment 2), the philosophical category was both slower and less accurate, and the physical category was both faster and more accurate. The results from Experiment 2 are more in line with what we would have expected in terms of concreteness effects. Generally, the physical concepts are rated as more concrete, and the philosophical concepts as more abstract, as acquired later and more through language than perception (e.g., Villani et al., 2019). Interestingly, these differences emerge only in a verbal task (Experiment 2), likely due to the different degrees of reliance of the two categories on linguistic experience. Our findings could have consequences for how and whether we view verbal and visual representations of the same abstract concepts as equivalent.

Inner Speech and Abstract Concepts

We hypothesized that inner speech might be involved in processing abstract concepts because it categorizes and delineates their meaning, and because it can be used to negotiate meanings between people and within one person. Do our results count against such ideas? To some extent yes, but it will have to be further explored in future studies using more disruptive interference tasks. Memory-based ones such as the types we used generally interfere less than more continuous types do (Nedergaard et al., 2022; Nedergaard et al., subm.). There was some evidence for verbal interference in the form of lower accuracy in Experiment 1 but verbal interference was also associated with faster response times, so we cannot exclude the possibility that the accuracy effect was due to a speed-accuracy tradeoff.

Conclusion

Interfering with inner speech does not appear to have clear detrimental effects on the processing of abstract concepts, at least not the kind of processing we test in the present odd-one-out paradigm. However, we did gain valuable insights about access to concepts (both abstract and concrete) through visual or verbal symbols. Future studies should test the present paradigm using verbal interference tasks that do not require maintaining stimuli in memory.

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