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What lies behind the "ambiguity disadvantages" when perceiving dual images?

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Abstract

Introduction. The focus of the problem of advantages and disadvantages of ambiguity is the question of whether it facilitates or hinders information processing. The relevance of the problem is due to the inconsistency of the available experimental data. Experiments do not take into account whether ambiguity is aware or unaware, but recording it could clarify the problem at hand. Our approach implies separating ambiguity that is both aware and unaware. In our study, we test the idea that the presence of unaware meanings provides greater concreteness of aware meanings compared to unambiguous stimuli. **Methods.** Stimuli were ambiguous figures. Subjects (n = 92) sorted two sets of cards, each containing one ambiguous figure, into a convenient number of classes. The operationalized hypothesis is that the classes into which images with unaware ambiguity fall will include fewer items than classes without ambiguous figures. **Results.** Intergroup comparisons revealed the differences expected according to the hypothesis: classes with ambiguous figures were more sparsely populated than classes with unambiguous versions of the same figures. **Discussion.** Rather than interpreting the result in favor of the disadvantages of ambiguity, we explain it by narrowing the equivalence range of an ambiguity stimulus, allowing the stimulus to be instantiated in an optimal way. The important role of unaware meanings in the process of interpreting perceived information is confirmed.

Keywords

ambiguous figures, unaware meanings, aware meanings, negative choice, positive choice, classification, ambiguity advantages, ambiguity disadvantages, range of equivalence, concretization

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Introduction

The prevalence of the problem of ambiguity perception cannot be overemphasized: incoming information almost always has several possible interpretations, some of which are cut off often before they are even realized (Tal & Bar, 2014; Kellner, Quement & Riener, 2022). The importance of understanding how ambiguity information is processed is emphasized in the current research literature (recent review: Rodd, 2018). Much attention has been paid to the problem of ambiguity advantage and ambiguity disadvantage in psycholinguistic research. The focus of the problem is whether ambiguity favors or, on the contrary, hinders information processing. The relevance of this problem is due to contradictory experimental data: in some cases, ambiguity favors stimulus processing (Haro, Demestre, Boada & Ferré, 2017; Haro & Ferré, 2018; Filippova, Kostina, Mezentseva, 2018; Tang, 2020; Tang, 2022), in other cases, on the contrary, it hinders it (Armstrong & Plaut, 2011; Filippova, 2011; Peterson, Cacciamani, Mojica, & Sanguinetti, 2012; Hoffman & Woollams, 2015; Leinenger, Myslín, Rayner, & Levy, 2017; Maciejewski, Rodd, Mon-Williams, & Klepousniotou, 2019; Maciejewski & Klepousniotou, 2020, Filippova, Chernov, & Gorbunov, 2023).

It has been repeatedly shown that lexical decision is accelerated for ambiguity words (homonyms), whereas semantic decision is slowed (e.g., Hino, Pexman & Lupker, 2006). The presence of multiple meanings speeds up lexical decision because this decision can be made according to whichever of the competing meanings is first to be realized. Semantic decision making, on the other hand, is reduced in the presence of multiple competing meanings, as it requires enumeration and evaluation of these meanings (e.g., Hino et al., 2006, Maciejewski G., Klepousniotou, 2020). It is still unclear whether semantic decision latency occurs at the level of processing the ambiguity word itself, as suggested

by the semantic competition model (Armstrong & Plaut, 2008; Kawamoto, 1993; Rodd et al., 2004), or only at the level of response selection, as suggested by the decision model (Hino et al., 2006; Hargreaves, Pexman, Pittman, & Goodyear, 2011). According to the semantic competition model, slowing arises because individual semantic representations compete for activation. And according to the decision model, slowing arises from difficulties in selecting a response with respect to an ambiguity stimulus: here, it is assumed that representations of all meanings are activated independently without interfering with each other. Studies supporting the decision model often use a semantic categorization task: here, a delay in the categorization of homonyms is revealed when homonyms need to be classified according to broad ('living/non-living') but not narrow ('animal/non-animal' or 'plant/non-plant') categories (Hino et al., 2006). The explanation for the results obtained in terms of the decision model is that the task of categorizing according to broad categories is more difficult: subjects need to find a large number of semantic features of the target word, which contributes to the interference of relevant and irrelevant features. Categorization into narrower categories, according to this model, is a simpler task, since the decision in this case is made on the basis of a small set of relevant features, and this ensures that irrelevant features can be cut off quickly.

However, in studies in this direction (advantages and disadvantages of ambiguity), the question of whether the selection and cutting off of irrelevant meanings occurs consciously (i.e., the question of awareness of ambiguity itself) is not discussed. The experimental conditions do not include a division of ambiguity into aware and unaware, which, in our view, renders the problem of cutting off irrelevant meanings lacking clarity. According to our ideas, whether ambiguity is realized or not is one of the key points in the discussion of the possibility of ignoring irrelevant characteristics of target stimuli, both in the semantic encoding of an ambiguity stimulus and in response selection.

In recent studies (Maciejewski et al., 2019; Maciejewski & Klepousniotou, 2020) using the priming paradigm, "ambiguity deficits" manifested themselves in the form of a slowing of the connectivity judgement of an ambiguity prime and target, with slowing found even in unrelated samples. To explain this nonspecific negative effect of ambiguity on connectivity judgements, the decision model was unsuitable because unrelated samples did not involve a conflict of responses. In addition, the authors of these studies recorded a specific component of evoked potentials (EP component), the N400 gain, at the time of presentation of an ambiguity word, but not at the time of response selection (Maciejewski & Klepousniotou, 2020). Evidence in favor of the semantic competition model was also obtained in our studies, where the presentation of verbal and non-verbal ambiguity stimuli was also accompanied by an enhancement of the N400 component (Filippova, Shcherbakova & Shtyrov, 2020). Based on our data, we can definitely state that the emergence of this EP component is related to the awareness of ambiguity. In our study, subjects performed the task of determining whether the presented stimulus was unambiguous or ambiguous. In this case, the correct recognition of ambiguous stimuli was accompanied by an increase in the N400 component.

The controversy surrounding the problem of ambiguity has fueled contemporary researchers' interest in studying the effects of suppressing competing interpretations (e.g., Kornmeier & Bach, 2014; Frings, Schneider, & Fox, 2015; D'Angelo, Thomson, Tipper, & Milliken, 2016; Rodd, 2018). What researchers, have neglected, however, is the question of what the presence of suppressed interpretations implies for the realized meanings of ambiguity information. Do realized meanings acquire any special properties when competing alternatives are suppressed? We pay attention to these questions in our research (Filippova, Allakhverdov, 2020; Filippova, Dorofeeva, 2023). The research builds on current scientific understanding that unambiguous clarity of aware experience requires a special unaware decision about which meanings will be realized and which will not (Dehaene & Changeux, 2011; Tal & Bar, 2014; Callaghan et al., 2017; Allakhverdov et al., 2019; Allakhverdov, 2021).

The study by Filippova and Allakhverdov (2020) used a judgement task to judge the relatedness of words and images. Images could be unambiguous and ambiguous. The images' ambiguity could indicate whether the subjects are aware or not. According to the results of this experiment, the unaware ambiguity condition had the highest number of errors of missing semantic relations compared to the other conditions. In another study implemented by Filippova and Dorofeeva (2023), an effect was found consisting in a rarer choice of word combinations related to the aware meanings of these logos as appropriate names of firms represented by ambiguous logos, compared to the choice of the same word combinations related to the unambiguous counterparts of these logos. We see the explanation of the obtained effects in the concretization of the aware meaning of ambiguity stimuli in the presence of unaware meanings. According to the ideas we have developed, the presence of unaware meanings narrows the range of equivalence (a term introduced by Gardner) of the realized meaning by assigning it to a narrow semantic category.

Although introduced as an individual variable, the range of equivalence is not rigidly defined. Current experimental evidence shows that the features of the stimuli presented also determine the breadth of the equivalence range. For example, Borghi et al. (2017) showed that the semantic domain of concrete concepts is narrower than that of abstract concepts, and therefore concrete concepts elicit fewer associations. V. D. Soloviev and colleagues using Russian nouns obtain confirmation of these findings in a recent study. According to the results of this study, the range of associations to concrete nouns is narrower than to abstract nouns (Soloviev, Volskaya, Akhtyamov, 2023).

The results of studies with illusory objects also suggest that the range of equivalence can vary depending on the perceived object and even its subjective interpretation. Different classification results can be obtained for the same object on the same subject. For example, in studies by V. Yu. Karpinskaya (2016) with illusory and ambiguous stimuli, when studying detection and distinction thresholds, it was shown that on a line or circle that subjectively seems larger, it is easier to notice a barely distinguishable point than on a seemingly smaller one (the geometric illusions of Ebbinghaus, Delbeuf, and Ponzo

were used). Similarly, on an element of an ambiguous figure that appears closer when one of its two meanings is realized, a barely discernible dot is easier to see than when the other meaning is realized (Necker's cube was used). This suggests that, depending on the interpretation of the object, the subjective equality zone of the stimulus sizes, or, in a broader sense, the range of equivalence, also changes in the subjects.

Following these observations, we suggest that the range of equivalence of ambiguity stimuli changes when they are realized as unambiguous: the field of activated associations of the realized meaning becomes restricted to close associations only. This explains, in our opinion, the semantic categorization results in the study by Hino et al. (2006), where a slowdown in the categorization of ambiguity words was observed when broad but not narrow categories were used. An alternative explanation given by these authors is that words with unaware ambiguity become more specific by activating a narrower semantic category, whereas the distant associations necessary for their categorization according to broader categories are suppressed in these words. Thus, we believe that the meaning of what is perceived is set not only by aware meanings, but also by unaware meanings that determine the perceptual context.

To further test this idea, the present study was implemented. Its **hypothesis** was that in free sorting, unaware ambiguity would influence the number of items in the classes created by the subjects: classes containing ambiguous figures would include fewer items compared to classes not containing ambiguous figures.

Methods

Preliminary coverage of the data from this study is given in the Proceedings of the Bruner Conference (Filippova, Chernov, 2022). Bruner (Filippova & Chernov, 2022). As noted in this paper, the operationalization of the hypothesis about the narrowing of classes containing unaware ambiguity implied two ways of testing:

1. In a between-group comparison, classes with ambiguous figures will include fewer items than classes without ambiguous figures.
2. In a within-group comparison, classes with ambiguous figures will include fewer items than classes with unambiguous versions of the same figures.

Sampling

The sample consisted of 92 subjects, students of St. Petersburg State University, aged 19 to 30 years (mean age 23 years, 58 women) with normal or corrected to normal vision. 46 subjects were assigned to the experimental group (EG) and 23 subjects to two control groups (CG1 and CG2).

Incentive materials

The target images in EG were ambiguous figures - "swan-cat" and "donkey-seal" (one in each set), and in CG1 and CG2 - their unambiguous analogues ("cat" and "seal" in CG1, "swan" and "donkey" in CG2). The rest of the cards for the three groups of subjects were identical. This distribution of target images across groups was necessary to compare the classification features of the aware meaning within the unaware ambiguity with the unambiguous version of the same figure under maximally similar conditions. The sets of cards used can be seen in Appendix 1 on the given classification examples.

Procedure and design of the experiment

The subjects' task in the realized experiment was to freely sort two sets of 34 cards into any number of classes. Each set contained one ambiguous figure.

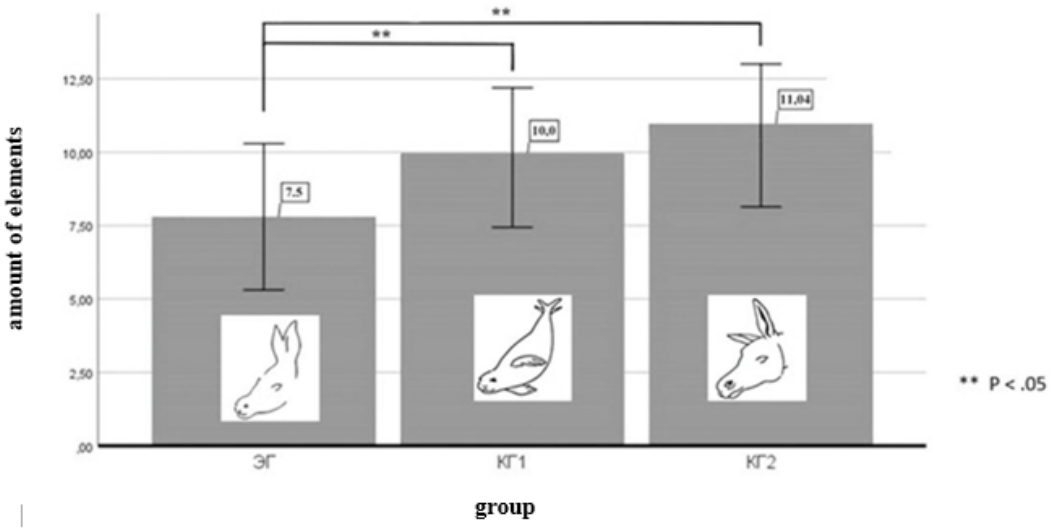
At the end of the experiment, the EG subjects, having the results of their classification in front of their eyes, answered the question about their interpretation of both ambiguous figures. When both meanings of any of them were realized, the classification results of the whole set including this figure for this subject were excluded from further analysis. As a result, data from four subjects who realized both meanings of the donkey-seal figure and data from nine subjects who realized both meanings of the swan-cat figure were excluded. These data were excluded rather than participating in the analyses of aware ambiguity because there were too few instances of awareness for a meaningful analysis in this condition.

The data were processed in the SPSS Statistics 2019 v26.0. The distribution of the number of elements in the classes created by the subjects differed from the normal distribution, so non-parametric criteria were used. The dependent variable was the number of elements in the class; the independent variable was the type of class (classes with unaware ambiguity , classes without ambiguous figures).

Results

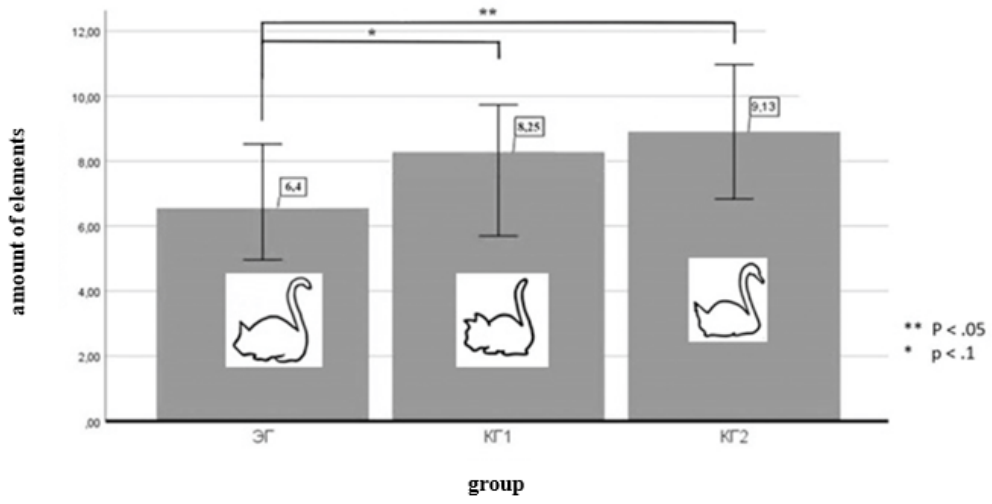
Based on the results of the within-group comparison, the number of items in the ambiguous figures class showed no significant differences from the number of items in the classes without ambiguous figures for either the first ($W = -0.982$; $p = 0.326$) or the second set of cards ($W = -1.282$; $p = 0.200$). However, intergroup comparisons revealed the differences expected under the second hypothesis. Thus, for the first set of cards, which included the donkey-seal figure, the differences between the three groups of subjects were significant ($H = 7.559$, $df = 2$, $p = 0.023$). Moreover, significant differences were found between both EG and CG1 ($U = 338$; $p = 0.045$) and between EG and CG2 ($U = 292$; $p = 0.016$). These data are presented in Figure 1.

Figure 1
Differences between experimental and control groups for the Donkey-Seal figure



For the second set, including the swan-cat figure, the differences between the three groups of subjects were also significant (H = 9.465, df = 2, p = 0.009). Moreover, between EG and CG1- the differences were at the trend level (U = 295; p = 0.052), and between EG and CG2- the differences were significant (U = 236; p = 0.004). These data are presented in Figure 2.

Figure 2
Differences between experimental and control groups for the Swan-Cat figure



As an illustration, Appendix 1 shows pictures of the results of the subjects' classification of both sets of cards with each of the target images.

Discussion

According to the results of the experiment, the first operationalized hypothesis was not confirmed: the number of items in the class containing the ambiguous figure did not differ from the number of items in the classes without ambiguous figures. The classes compared were too unequal for comparison, as it is not possible to take into account all variations in the arrangement of stimuli into classes to equalize them when creating stimulus material. However, an intergroup comparison of classes containing an ambiguous figure or its unambiguous counterpart (i.e., using as similar a condition as possible) revealed the differences expected under the second hypothesis: classes with ambiguous figures contained significantly fewer items than classes with their unambiguous counterparts.

This result is consistent with our earlier findings (Filippova & Allakhverdov, 2020; Filippova & Dorofeeva, 2023) and supports the idea that unaware ambiguity contributes to narrowing the range of equivalence of its aware meanings. However, instead of interpreting this result in favor of the disadvantages of ambiguity (because the reduction in the number of class elements, as in the present study, the omission of associations, as in the study by Filippova and Allakhverdov (2020), and logo names, as in the study by Filippova and Dorofeeva (2023), would be interpreted as disadvantages in the context of the theory of advantages and disadvantages of ambiguity), we explain it by the narrowing of the equivalence range of ambiguous stimulus, which makes it possible to concretize this stimulus in an optimal way.

The obtained results suggest an important role of rejected meanings in the process of interpreting incoming information, confirming the idea that the meaning of what is perceived is set not only by aware meanings, but also by unaware meanings that clarify the boundaries of the perceptual object. Explaining the obtained results, we proceed from V. M. Allakhverdov's concept of negative choice (Allakhverdov, 2021; Allakhverdov et al., 2019), which states that, perceiving an object, a person determines not only what this object is (positive choice), but also what it is not (negative choice). According to the ideas of this concept, simultaneously with recognizing an object as belonging to a category (positive choice), we also recognize it as a representative of some other categories, but we choose them negatively, i.e. we do not realize them. For unfamiliar objects, the categories are at first overly broad, but as we become familiar with the object, they narrow down. Concretization of the concept takes place, among other things, due to the exemption from unimportant features. Unaware meanings play an important role in such concretization, contributing to the narrowing of the semantic domain to which aware meanings belong.

This approach allows us to find expediency in what is commonly considered to be a characteristic of limited human abilities. This refers to the human tendency to overlook

multiple meanings, which has been pointed out by many authors (e.g., Rodd, Gaskell & Marslen-Wilson, 2002; Tal & Bar, 2014).

So what's behind the "ambiguity disadvantages"?

According to the view we are developing, the ambiguity disadvantages mask the provision of unambiguous clarity to aware experience (i.e., experience represented by aware meanings) by means of suppressed meanings that support the context chosen for awareness.

Conclusions

1. In the free sorting task, classes containing ambiguous figures with unaware ambiguity consist of fewer elements than classes without ambiguous figures;
2. Unaware ambiguity contributes to the concretization of its aware meanings;
3. The meanings rejected in the process of interpreting the meaning of incoming information provide the context of perception by narrowing it down.

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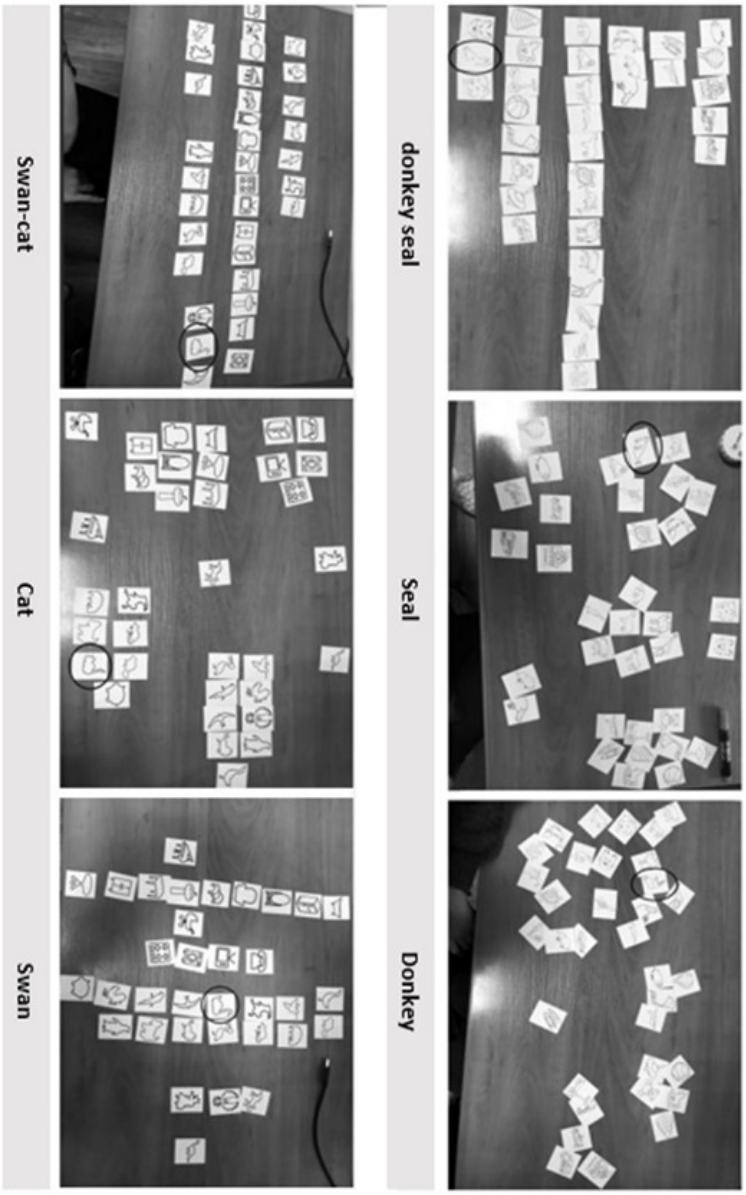
Annex 1

Example of subjects' classification of both sets with different target images (EG, CG1 and CG2)



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Author Contributions

Margarita Georgievna Filippova – concept and design of the work, analysis of literary sources, editing of the version for publication.

Natalia Vladimirovna Andriyanova – analyzing literary sources, drafting the text of the article.

Roman Vasilievich Chernov – data processing and description of results, drafting the text of the article.

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Conflict of Interest Information

The authors have no conflicts of interest to declare.