Journal of English language Teaching and Learning

University of Tabriz

Volume 14, Issue 30, (Fall and Winter 2022)

The Effectiveness of Radial Categories in Facilitating EFL Learners' Cognitive Operations for Learning Phrasal Verbs

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ARTICLE INFO:

Received date:
2022.06.16
Accepted date:
2022.07.31

Print ISSN: 2251-7995
Online ISSN: 2676-6876

Keywords:

Radial Categories, Phrasal Verbs, Cognitive Linguistics, Cognitive Load

Abstract

Mastery of English phrasal verbs is regarded as a stumbling block for English language learners, even at advanced levels. Possible sources of difficulty can be a lack of clear meaning and the random nature of particles. The lack of an organized approach to present phrasal verbs to the learners might be a factor that could exacerbate the situation of learning them. This study takes this issue as its point of departure. It investigates whether employing radial categories, conceptual categories with one prototypical concept and some peripheral members that are organized around it, is influential in the learning and long-term retention of these verbs. Moreover, the effect of employing radial categories to teach PVs on learners' cognitive load is investigated. For this purpose, 60 intermediate high school students in 10th and 11th grade were assigned to two groups, one experimental and one control group, each containing 30 students. The study results indicated that the experimental group learners who were taught phrasal verbs using radial categories outperformed control group learners who were taught using a traditional approach. This result suggests that radial categories may help facilitate learning phrasal verbs.

DOI: 10.22034/ELT.2022.52114.2498

Citation: Mehrad Sadr, M.; Hesabi, A.; Shahnazari Dorcheh, M. (2022). The Effectiveness of Radial Categories in Facilitating EFL Learners' Cognitive Operations for Learning Phrasal Verbs. *Journal of English Language Teaching and Learning*, 14(30), 149-164. Doi: 10.22034/ELT.2022.52114.2498

1. introduction

Phrasal Verbs (henceforth PVs) are combinations of verbs and prepositions, adverbs, or particles with a certain degree of idiomaticity. That is, the whole of a phrasal verb has a meaning which is more than the sum of its parts. Being assigned more than one meaning, having complex grammar, having collocational links with other words, and changing in meaning as language develops, phrasal verbs are difficult to learn for language learners (Sinclair, 1989). Learning PVs is a critically important part of the English lexicon for EFL learners, due to their dominance in English spoken and written language. Even gaining mastery over these verbs is counted as a true indication of language proficiency (Cornell, 1985). The way PVs have been traditionally taught or presented in the books makes the situation of learning these verbs worse (Side, 1990; Tyler & Evans, 2004). In traditional approaches, phrasal verbs were believed to be unsystematic and arbitrary (Thom, 2017); therefore, the most common approach for teaching them was to make learners memorize a long list of haphazard PVs.

Cognitive linguistics (henceforth CL), unlike traditional approaches, discusses that lexicon, in general, and particles, in particular, are systematic and rule-governed (Tyler & Evans, 2004). Cognitive linguistics has a particular perspective in interpreting particles in which their meanings refer back to their prototypical meaning as adverbs of time and place (Lindner, 1981; Tyler & Evans, 2003). Other senses are radiated from this central meaning by using metaphor or metonymy (Lakoff, 1987).

Rosch (1975) was the first one who discussed the concept of radial category in cognitive psychology. She contended that categories have 'a best example' or 'prototypical member' that is in the center of the category, and the other members of the category are organized around it. Lakoff (1987) developed the ideas of Roach for radial categories. Like Roach, he believed in the fuzziness of the boundaries when one sense merges into the other. Members of the category extend from the prototype through metaphor and metonymy until the peripheral members are categorized in neighboring categories as well. Because some peripheral members may be connected to a non-prototypical example, they may not seem to be related to some other members of the category. A prototype, as Lakoff (1987) argues, is the only member to which all of the other members are connected in one way or another. The relationships between different senses in a category are not arbitrary, but they are systematic and organized (Brugman & Lakoff, 2006). The prototype can be related to other members by sharing some features as, for example, all books have covers and pages. A prototype can also be a typical example of the sense to which all other members have a degree of similarity.

Polysemy, a linguistic form with more than one distinct meaning, is one application of the notion of the prototype. The word fruit, for instance, has some prototypes like apple and banana and some less prototypical examples like coconut and olive (Robinson & Ellis, 2008). Nevertheless, in examples like *the fruits of my labor or my work bore fruit*, the fruit is used in instances in which the prototypical or even less prototypical examples cannot be inferred, and are examples of meaning extensions of the word (*Geeraerts, 1997*). This identifies that the word fruit has distinct, identifiable meanings, so it is a polysemous word.

Particles of PVs can also be categorized based on radial categories. As an example from Rudzka-Ostyn (2008), the particle *out* in phrasal verbs has a prototypical meaning as '*leaving a container*" to which other peripheral meanings are connected like:

1. Entities moving out of container: cut out, jump out
2. Eat or invite to eat away from home: ask out, eat out, invite out
3. Sets or groups are containers: cut out of, sort out
4. Bodies, minds, and mouths are containers: think out, reach out
5. States/ situations are containers: be out of, run out
6. Non-existence, ignorance, invisibility as containers: turn out, find out
7. Trajectories increasing to maximal boundaries: spread out

Lakoff (1987, pp. 416-419) defines polysemy as follows: "The different senses of a polysemous word make a 'category of senses' with one central more representative member and some peripheral members which are extended from it." Therefore, polysemy and all other linguistic relations can be explained by radial categories. The radial category allows the linguist to investigate the variety and coherence of related items simultaneously, rather than attending to one of them and leaving out the others. In this way, even the most disorganized range of related items can be seen as a unified category (Janda, 2015).

The radial categories are structured around a core or central meaning to which other peripheral members are connected. Lamb (1999), in his relational network theory, explains that linguistic information is a network of interrelationships. This system is accessed using multiple strata, including phonetic, conceptual, and perceptual strata. His theory proposes a neurological justification of radial categories. It suggests that a linguistic information system is represented through a relational network. When a stimulus or a series of stimuli triggers a node of the network, the other corresponding pathways and related concepts are activated as well. Therefore, by stimulating one conceptual node, other conceptual and perceptual nodes are also activated.

The radial categories are naturally formed in the minds of the native speakers when they encounter different senses of concepts in various situations every day. Mahpeykar (2008) found that non-native speakers, however, mainly use the literal or prototypical sense of the words, i.e., those in the center of categories, and avoid using those lying at the edges of the categories. The same can be true for phrasal verbs as one specific aspect of the lexis-grammar continuum. Danesi (1993) reports that learners use phrasal verbs at the center of each category and avoid those in the periphery.

There is a difference between native and non-native speakers in the case of how they use members of radial categories. Littlemore (2009) indicates that native speakers use peripheral members of the category, those which have figurative senses, more than non-native speakers. In contrast, non-native speakers tend to use the prototypical sense more than peripheral figurative senses. Littlemore suggests that these findings from advanced level students who

had regular communication with native speakers daily are due to either not noticing these figurative uses in spoken data or knowing the senses but not having the confidence to use them.

Littlemore and MacArthur (2012) found that even advanced learners had limited awareness of the words included in the periphery of the categories compared to native speakers. In addition, they found that substantial variation in the knowledge of the category members of the words can be traced among native speakers. The younger the speakers, the lower their knowledge about peripheral members of the categories. These findings suggest that the knowledge of radial categories emerges over time and in communicative contexts, not in educational decontextualized contexts that place more emphasis on usage rather than the use of the language. Mahpeykar (2008) found that not only do non-native speakers use figurative or peripheral senses less than native speakers, but they also have fewer categories in their corpus. That is, non-native speakers lack some categories altogether.

Concerning PVs, not surprisingly, many learners of English, even advanced ones, do not have mastery over these verbs and rarely use them in their speaking or writing. They also have problems with the meaning and form of these verbs (Rudzka-Ostyn, 2008). Ghabanchi and Goudarzi (2012) and Palash (2017) found that Iranian EFL learners used PVs significantly lower than native speakers, even to the advanced levels. Also, the results of Ghabanchi and Goudarzi (2012) indicated that non-native speakers significantly preferred literal phrasal verbs more than figurative ones.

Employing cognitive approaches for presenting PVs provides teachers with tools to help learners figure out the non-arbitrariness in PVs. Over the past decades, different studies investigated the effect of taking a cognitive linguistic approach to teaching PVs (Boers, 2000; Condon, 2008; Condon & Kelly, 2002; Farsani et al., 2012; Kovecses & Szabco, 1996; Sadri & Talebinejad, 2014; Sadri & Talebinezhad, 2013). The results of almost all of these studies favor a CL approach for teaching PVs. What is not found in the prior studies is investigating the effect of providing learners with PVs instruction based on the radial category of phrasal verbs and also giving them illustrations based on the network for each category of PVs.

Another issue that needs to be considered is the learners' cognitive load. Cognitive load is supposed to be related to working memory capacity (Paas & Sweller, 2014). Suppose a category with one prototype accompanied by examples and explanations for all PVs in the category is going to be presented to learners. In that case, the working memory capacity needs to be considered. Since the working memory capacity is limited, both instructional design and learning material affect the interaction between the learners, the learning material, and the amount of mental effort they experience (Lin et al., 2013; Paas & Sweller, 2014). Therefore, it indicates the need for exploring the interaction between the learning method, the learning material, and the learners' cognitive load. Previous studies limited the number of PVs in each session to one (Farsani et al., 2012) or two (Sadri & Talebinezhad, 2013) or divided the class time to two 20-minutes with a break (Csábi, 2004) to avoid overloading learners with cognitive insights. Besides, Condon (2008) considered cognitive load a factor that was probably the reason behind one of his experimental groups' lack of success.

Cognitive load is related to the resources that an individual's working memory use at a specific time (Sweller, 1988). Based on the Cognitive Load Theory, cognitive load is defined

as a three-component construct including intrinsic, germane, and extraneous load. Intrinsic load refers to the nature of the material itself and cannot be avoided. Germane cognitive load is related to the actual processing resources required to perform the task. Extraneous load refers to the complexity of the representation of the task, which can vary based on how the task is presented. The task complexities of task representation can be minimized to free working memory capacity for more processing in intrinsic load (Sweller et al., 1998). Based on the Cognitive Load Theory, efficient instruction is the one that has low extraneous load and optimal germane load (Van Gerven et al., 2002). In this study, the learners' cognitive load was controlled by presenting PVs in radial categories rather than a list of haphazard verbs also by using Prezi for presenting PVs.

In sum, the studies mentioned above suggest that teaching phrasal verbs by employing the radial categories would help English language learners master not only the prototypes in each category of phrasal verbs but also the peripheral senses in each category. The present study takes this hypothesis as its point of departure. It examines whether presenting PVs using radial categories enhances EFL learners' learning of central and peripheral PVs in each category. It also aims to determine the effect of employing the radial category to teach PVs on the learners' cognitive load.

The following research questions were formulated in order to put the issues mentioned above into practice:

1. To what extent does the employment of radial categories to teach PVs facilitate learning PVs in contrast to traditional approaches (e.g., using dictionary definitions, providing examples, and single verb equivalents?

2. To what extent does the employment of radial categories or a traditional approach for teaching PVs affect the learners' cognitive load?

The subsequent hypotheses were formulated considering the research questions mentioned above.

H1. Students instructed phrasal verbs by using radial categories have higher scores than those instructed by the traditional approach (e.g., using dictionary definitions, providing examples, and single verb equivalents)

H2. Students instructed phrasal verbs using radial categories have lower levels of the cognitive load than those instructed using the traditional approach.

2. Methodology

2.1. Participants

Before starting the main sampling procedure, a group of 47 high school students in 10th and 11th grades was selected for the piloting phase of the study. The pilot group participants were selected based on their similarity to the study population. The main study participants were sixty high school students in the 10th and 11th grades. They were selected out of 239 students who agreed to participate in the study from five public schools in Isfahan. Due to the pandemic of Covid-19, direct contact with learners was not possible; therefore, all participants were asked to join a study group on WhatsApp. The OPT (2020) electronic form, which was in the google forms format, was sent to all participants. Intermediate learners were selected for the study

based on the OPT test results. Seventy-eight students who were at an intermediate level were randomly assigned to the two groups of the study (an experimental and a control group). All participants were females, and their ages ranged from 16 to 18 years. At the end of the study, some participants were excluded from the data analysis. The excluded participants were those who missed some necessary tests and those who were absent for three or more sessions. Therefore, the final number of participants comprised 60 altogether, with 30 participants in each group.

2.2. Instruments

2.2.1. Oxford Placement Test (OPT) 2020

An OPT (2020) was administered to measure the participants' level of English.

2.2.2. Cognitive load scale

Cognitive load was measured by the subjective self-rating scale of Paas (1992), which is a 9-point subjective rating scale. It asks respondents to measure their mental burden of the task from a very, very low mental effort to a very, very high mental effort. The scale items were translated to Persian, and the translated version was piloted in the pilot group. The Cronbach's alpha coefficient was measured in order to check the reliability of this scale, and it was .94, which is a high-reliability index for the scale. Also, the wording of the items was checked with the pilot group. Some modifications were made to the items based on the comments of the pilot group to make them more transparent for the respondents. The participants rated their level of mental effort using this scale at the end of each session. The participants' responses to the scale were summed across all six sessions and then divided by six, thereby generating a measure of average perceived mental effort with values ranging from 1 to 9.

2.2.3. Pretest, Posttest, and Delayed Posttest:

This study employed a multiple-choice recognition test with 40 items designed to measure six categories of PVs, including the up, down, on, off, in, and out PVs. Each category of PVs, e.g., up, down, in, out, on, off, contained 6-7 items. After designing all of the items, four experts in applied linguistics were asked to read the items and check the tests for content validity. Modifications were made to the test based on the suggestions made by the experts. Next, the test was performed on the pilot group. After that, the pilot group results were fed to the KR-21 coefficient formula to measure the reliability of the test. KR-21 coefficient of the test was .90, which indicates high indices of reliability.

2.3. Procedures

Before the official commencement of the experiment, the treatment was piloted in the pilot group, including 47 10^{th} and 11^{th}-grade high school students. For the pilot group of learners, different platforms were employed for the main teaching processes to figure out which one works better for their situation. The use of Big Blue Button, Google Meet, and Zoom platforms faced some disconnections and also some dropouts of the learners during the sessions. Therefore, a similar platform named Skyroom was employed in the end with chatting and multimedia sharing abilities. All sessions were done with few problems for learners and the teacher on this platform. Thus, Skyroom was chosen for the treatment of the four groups of the main study.

After the pilot study, the problematic points were diagnosed and cared for in advance. An OPT (2020) was taken from all 10th and 11th-grade high school students from five high schools who agreed to participate in the study. Based on their scores on the test, those who were at an intermediate level were chosen for the study. After that, learners were randomly assigned to the experimental and control group. The pre-test, including 40 multiple-choice tests, was administered to the four groups of the study. The pre-test results were then compared to see if the two groups of the study were different in their knowledge of the PVs before the study. Both groups were found not to be different in their background knowledge of PVs in the pre-test. PVs made of six most frequent particles: in, out, on, off, up, and down were selected from the list of the most frequently used English phrasal verbs in American and British English, which were further ranked by their most frequent senses by Liu (2011). The selected PVs were then taught to the experimental and control groups of the study in 12 sessions (2 sessions for each group of PVs). Due to the pandemic of Covid-19, all classes were held virtually. The main groups of the learners were on WhatsApp and were used for announcements and some class practices. The Prezi virtual presentation platform was employed to illustrate the categories of each PV. Each category of phrasal verbs was taught to the learners in two sessions. Some cloze tests were also given to the learners before and after each session. The cloze tests were used as a kind of practice for the learned PVs in each session.

To control for the multimedia and explanation effects, all pictures and sentence examples for PVs were the same for both study groups. Only in the experimental group were PVs illustrated in categories and connected to the central meaning. The way each verb was connected to the central meaning was explained using the explanations in Rudzka-Ostyn (2008) and Tyler and Evans (2003). The primary sources employed for illustrations and categorizations of PVs were the two mentioned sources. Rudzka-Ostyn (2008) was used as the first source of treatment. Tyler and Evans (2003) was employed to clarify and elaborate on one sense, especially those senses that the explanations in Rudzka-Ostyn were not clear enough for learners.

Lesson plans for both groups were prepared and sent to four applied linguistic experts. Based on their comments and after some considerations and revisions, they were applied to both study groups. The procedure for each group is as follows:

Group 1:

In group one, the experimental group, the radial category was employed to teach PVs. In this class, the sessions started with some practices, including a cloze test to measure learners' background knowledge of the PVs, which they were going to learn in the scheduled session. Then PVs were taught one by one, beginning with the central meaning and going through the peripheral meanings and PVs in each category. Each category of PVs took two sessions to complete. At the end of the second session, when the whole category was taught, the cloze test practiced before the class was worked on to see how much the students had learned from the lesson. Figures 1 and 2 indicate the category for UP PVs and one example of the explanations and examples of PVs. Both pictures are from Prezi virtual illustration website.

Figure 1. *Radial category for UP PVs*

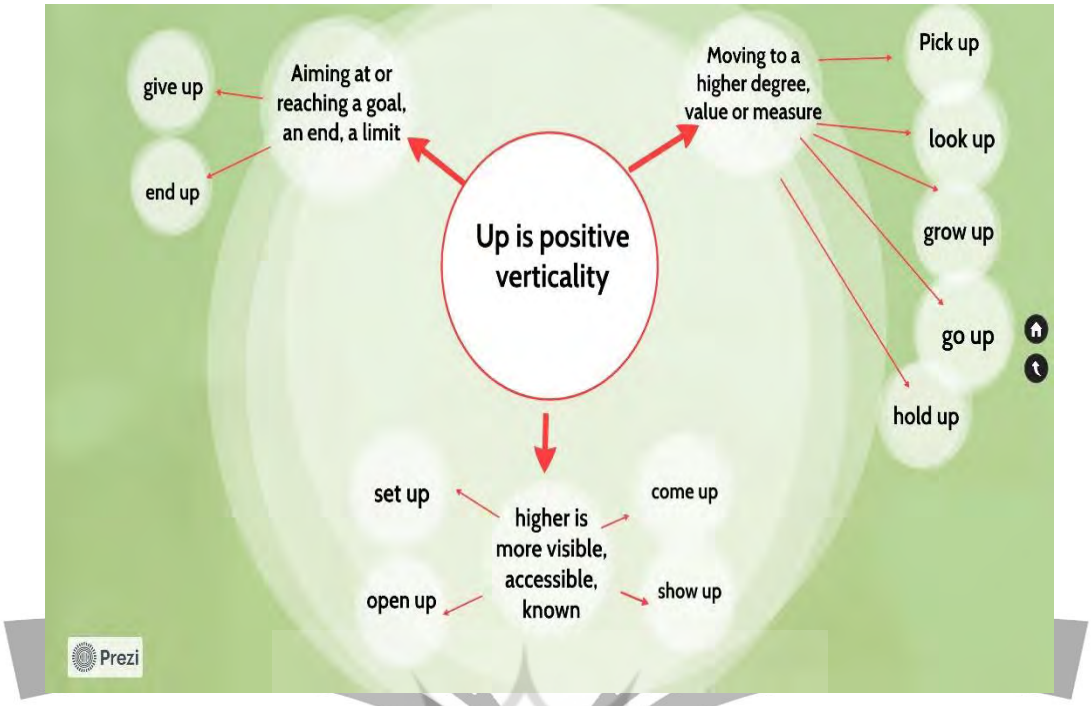

Figure 2. *The explanation, examples, and pictures for the verb "pick up".*

Group 2:

In group 2, the exact pictures and sentence examples presented to learners in experimental groups were also used for teaching this group. Some translations were also used to clarify the meaning of PVs. Just in this group, there was no mention of the connections among PVs. Although all verbs in a category, e.g., UP PVs, were taught together, there was no mention of any relationship or category among these verbs. Figure 3 indicates the PVs taught in the UP session in the control group of the study.

Figure 3. *UP PVs which were presented to the control group*

As the picture shows, all UP PVs were taught together without mentioning the categories. In this group, the class sessions started with doing some tests. These tests included a cloze test aiming at measuring the background knowledge of the learners of the PVs meant to be taught in the session. Then PVs were taught using Prezi presentation software. At the end of session 2, when the whole verbs in a group of PVs were entirely taught, the cloze test presented at the beginning of the session was worked on again to practice the taught verbs.

At the end of each session, all learners were asked to rate their cognitive load using the cognitive load scale by Paas and Van Merriënboer (1993). At the end of the course, the post-test was administered to measure the learning of PVs in each group. Also, two weeks after the final session, the delayed post-test was administered to measure the retention of PVs in each group.

Results

The results of the study are presented in the following sections. Table 2 indicates some descriptive statistics from the data, including the experimental and control groups' mean and standard deviation.

Table 1. *Mean and standard deviation for pre-test, post-test, and delayed post-test of the experimental and control group*

	Group	N	Mean	Std. Deviation
Pre-test	Experimental	30	28.40	5.568
	control	30	26.33	4.188
Post-test	Experimental	30	33.80	6.233
	control	30	26.80	5.678
Delayed post-test	Experimental	30	33.17	5.490
	control	30	26.10	5.142

A glance at Table 1 indicates that there was an increase in the learners' scores in the post-tests of both groups. While regarding the post-test and delayed post-test of both groups, a minor reduction in scores could be found. An independent sample T-test was run to see whether the experimental and control groups' differences between the pre-test, post-test, and delayed post-test were significant. The result of the T-tests and other follow-up tests are presented based on the research questions and hypotheses of the study.

Regarding the first research question, to investigate to what extent applying radial categories to teach PVs facilitates learning PVs in contrast to the traditional approaches like using dictionary definitions, providing examples, and single verb equivalents, an independent sample T-test was employed.

Before investigating the first research question, an independent sample T-test was run to investigate whether the two groups of the study were different in their knowledge of phrasal verbs before the study. Table 2 indicates the T-test analysis result for the two groups' pretest. As the table indicates, the *P* value for the test is not significant (P>.05). Therefore, both groups of the study were not significantly different before the study.

Table 2. *Independent sample T-test for pre-test, post-test, and delayed post-test of the control and experimental groups of the study*

	Levene's Test for Equality of Variances		t-test for Equality of Means		
	F	Sig	t	df	Sig. (2-tailed)
Pre-test	3.305	.074	1.625	58	.110
Post-test	.351	.556	4.547	58	.000
Delayed post-test	.493	.485	5.146	58	.000

However, the result of the independent sample T-test (Table 2) for the post-test of the two groups reveals that there is a significant difference between the two groups of the study regarding their post-test scores (p <.001). Also, based on the results of the delayed post-test scores (Table 2), this difference was retained in the long run (p <.001).

The next research question and its equivalent hypothesis were meant to investigate to what extent applying radial categories or a traditional approach for teaching PVs affected the cognitive load of the learners. Table 3 indicates the mean and standard deviations of the cognitive loads of the learners in the two groups of the study.

Table 3. *Mean and standard deviation for the cognitive loads of the learners in the experimental and control group*

	Group	N	Mean	Std. Deviation
Cognitive load	Experimental	30	۵,۳۱۶	.246
	control	30	۵,۶۳۶	.149

Table 4 indicates that the mean cognitive load is lower in experimental group learners than in control group learners. However, the *P* value for the test is not significant (P>.05). Therefore,

the .322 mean difference in cognitive loads between the experimental and control groups was not significant.

Table 4 *Independent sample t-test for the cognitive load of the experimental and control groups of the study*

	Levene's Test for Equality of Variances		t-test for Equality of Means			
	Sig	F		df	Sig (2-tailed)	
Cognitive load	3.096	.084	-1.119	58	.268	-.322

3. Discussion:

Regarding the first research question, the analysis and comparison of group performance indicated that the two groups of the study had approximately the same knowledge of PVs in the pre-test. However, at the end of the experiment, the experimental group which was taught PVs using radial categories outperformed the control group significantly regarding the taught PVs, and this difference remained in the long run as the result of the delayed post-test (two weeks later) revealed.

The result lends strong support to the hypothesis that CL instruction to teach PVs leads to better outcomes for the acquisition of these verbs compared to traditional approaches like memorizing a list of phrasal verbs, learning the dictionary meaning, or learning the translation of the verbs in their language. The result confirms the outcome of the previous studies in wide-ranging CL-based approaches, which have tried to find a way for the problems of foreign language learners in learning PVs (Boers, 2000; Condon, 2008; Condon & Kelly, 2002; Farsani et al., 2012; Kovecses & Szabco, 1996; Sadri & Talebinejad, 2014; Sadri & Talebinezhad, 2013). However, the findings of this study make a unique contribution to the application of radial categories and provide learners with the PVs in networks of related meanings. The results of this study support the usefulness of this approach. A shortcoming in previous research was providing visual aids for the experimental group learners but not for the control group learners (Condon, 2008). This study tried to control some variables by providing the same situation in both experimental and control groups in the case of:

1. Pictures used for illustration of PVs,
2. The media for presentation, which was Prezi for both groups,
3. Sentence examples which provided the context for learning PVs,
4. Even the PVs which were presented in each session.

By controlling the variables mentioned above, this study attempted to limit the variables that could influence the outcomes and just make a distinction between the experimental and control groups by providing the radial categories and presenting verbs in their semantic networks for the experimental group while using sentence examples, translation, or dictionary definition for teaching PVs to control group. Also, by cautiously controlling the variables, this study tried to distinguish between the effect of categorization in general or a CL categorization. That was done due to the previous findings that suggested grouping the teaching items, e.g., groups of PVs with the same particle is helpful for memorization in psychological studies

(Boers & Lindstromberg, 2006). In this study, even the control group learners received all PVs with the same particle together; therefore, the result of this study indicates the superiority of a CL categorization of PVs over generally teaching PVs with the same particle together.

This result may have been achieved because it helped learners in the experimental group to categorize the PVs of each group around a central meaning in their mind and also made the link between the central and peripheral meanings more salient to them; therefore, it brings them out of the confusion that they feel with learning these verbs in traditional approaches.

Comparing the results of the delayed post-test and the post-test indicated that learners could retain their knowledge of PVs gained during the treatment for a long time. The reason behind the superiority of the experimental group, in the long run, lies in the fundamental idea behind the assumptions of radial categories. Radial networks can explain how some concepts and conceptual areas are connected in the minds of speakers of a specific language (Lee, 2001). Lamb (1999) has indicated a similarity between the structure of the brain and the structure of radial categories. In other words, radial categories are neurologically justifiable. Also, the radial network for PVs probably helped them make or complete part of the schemas for PVs with a specific particle in their mind; therefore, the participants could retain this network in their long-term memory.

Regarding the second research question and hypothesis, the experimental group learners who were taught PVs using radial categories did not experience significantly lower levels of the cognitive load than the control group learners who were taught using a traditional approach. However, both groups are not considered to be overloaded. This result probably happened due to closely controlling the experimental situation to differ only in the CL categorization provided for the experimental group and maintaining all other variables the same for both groups. Some variables like grouping PVs or using Prezi (Akgün et al., 2016) have been shown to have a positive effect on reducing cognitive load for the learners.

Although the mental effort did not differ across different conditions of the two groups of the study, one should note that at the same level of mental effort during instruction, those who were taught PVs using radial categories had higher gains and could retain what they had learned for a long time. Therefore, the results confirm the efficiency of employing the radial categories in teaching PVs, regardless of the amount of mental effort imposed on the learners.

4. Conclusion

This study has contributed to the knowledge in the area of CL-based instruction of phrasal verbs. This study has complemented previous studies on the following points:

1. Providing PVs with central and peripheral meaning in the radial category and making the links between the central and peripheral meaning clear for the learners to make learning and retention of these verbs easier.
2. Controlling the effect of grouping by providing the phrasal verbs in groups for both experimental and control groups of the study.
3. Controlling the effect of illustrations and sentence examples by providing the same platform, Prezi, and the same picture and sentence examples for both study groups.

4. Making simple descriptions to link between central and peripheral meanings more precise for the learners in the experimental group.
5. Selecting verbs from the list of most frequent PVs in their most frequent senses.

In sum, the results of the study indicated that CL-based instruction, in general, and radial categories, in particular, were quite beneficial for the learning and long-term retention of PVs.

This approach was not enough to lower the cognitive load of the learners. Other variables which are influential in cognitive load need to be examined in order to be able to benefit from both the enhanced learning of a CL-based approach and a reduction in levels of cognitive load. An approach mentioned in previous studies as a way of reducing overload is the flipped approach in which the educational material is sent to the learners some days before the main session; therefore, learners have time to learn at their own pace and reflect on what they are learning. In this way, their cognitive load is expected to be lower than in a conventional class. Therefore, the effect of this approach is suggested to be studied to be able to fully exploit the benefits of a CL approach like radial categories.

The findings of the study lend strong support to the beneficial contribution of the CL-inspired approach compared to the traditional approach in learning PVs and long-term retention of these verbs. This superiority may originate from the theories of radial categories in which particles are not considered arbitrary but are cognitively categorized in semantic networks. This cognitively-based instruction will allow learners to achieve a more profound knowledge regarding the spatial meaning of particles as their core meaning and the peripheral meanings. It also helps them retain this knowledge of PVs in their long-term memory and even gain confidence in using them when they know that PVs are not arbitrary but are systematic and rule-governed and are categorized in semantic networks with one central meaning and some peripheral meanings attached to it. It may additionally help them use these verbs more often. Another implication of the study is for the material designers that could benefit from the findings of this study in designing and mentioning practices to present PVs. Also, Prezi provides a beneficial platform that can accelerate the presentation of the transition of PVs from central to peripheral meanings.

Finally, to address some limitations of this study, it goes without saying that although this study focused on six particles of PVs, which are more than what has been worked on in previous studies on PVs, there are many more particles and related PVs that need to be taken into account. Also, having a larger sample and extending the teaching of PVs in the long term can provide more generalizable results.

Another point is related to the cognitive load of the learners. Since meaningful learning, in general, and learning PVs, in particular, involve a considerable amount of cognitive processing in both verbal and visual channels. They also include paying attention to the presented material while organizing the received material in mind and integrating it with existing knowledge. Consequently, there is a high probability that both visual and verbal channels are overloaded with essential processing demands (Mayer & Moreno, 2003). Especially when in the case of our study, the content is rich, and the pace of information is fast, learners may not find enough time to process verbs in the verbal channel and images in the visual channel and simultaneously

organize and integrate them. By the time the learner tries to process one part, the other part begins and does not allow the learner to engage in deep processing. This situation is one example of what Sweller (1999) calls 'material with a high intrinsic load.' Since the use of the radial category has positive effects on learning PVs, it is possible to use some ways to reduce the cognitive load of the learners while using this approach for teaching PVs.

One solution suggested by Mayer and Moreno (2003) for lowering the cognitive load is to break the material into some bite-size segments. Therefore, it gives the learner enough time to organize and integrate the material before moving to the next part. Another solution is to mix the radial categories approach with other approaches like flipped learning which proved to help lower the cognitive load of the learners (Paas, 1992; Turan & Goktas, 2016) because the pace of learning is more learner-controlled and, again the learner can pause, learn, reflect, organize, and integrate the material based on their speed of learning. It can enhance the benefits of a cognitive approach.

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