

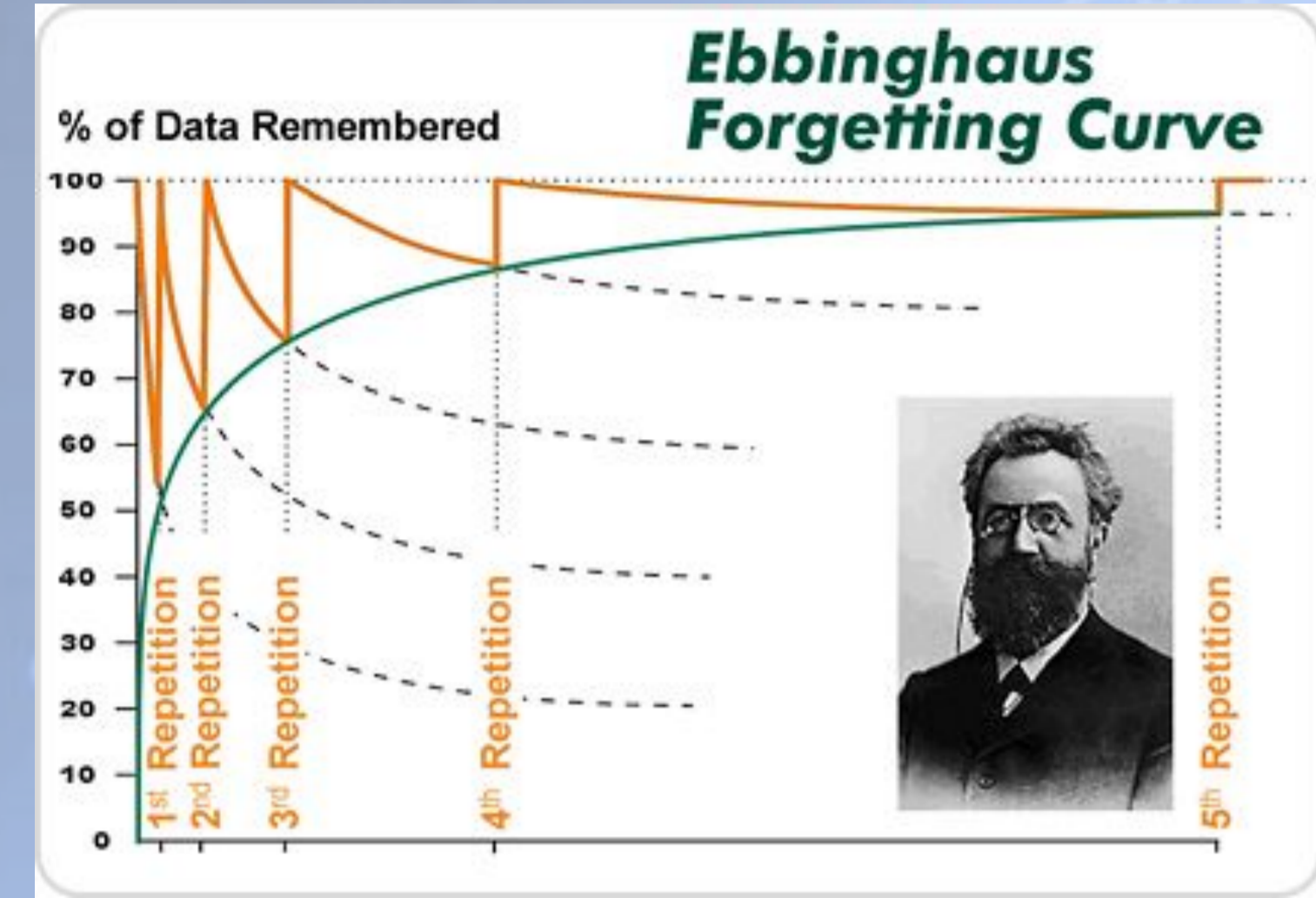
# Indirect / Interleaved Spaced Repetition Software (ISRS) as a Vocabulary Learning Tool



Ideas for the next generation of spaced repetition systems: to further explore deliberate flashcard study, to seek out new algorithms, and new interleaved tasks to boldly go where no spaced repetition system has never gone before

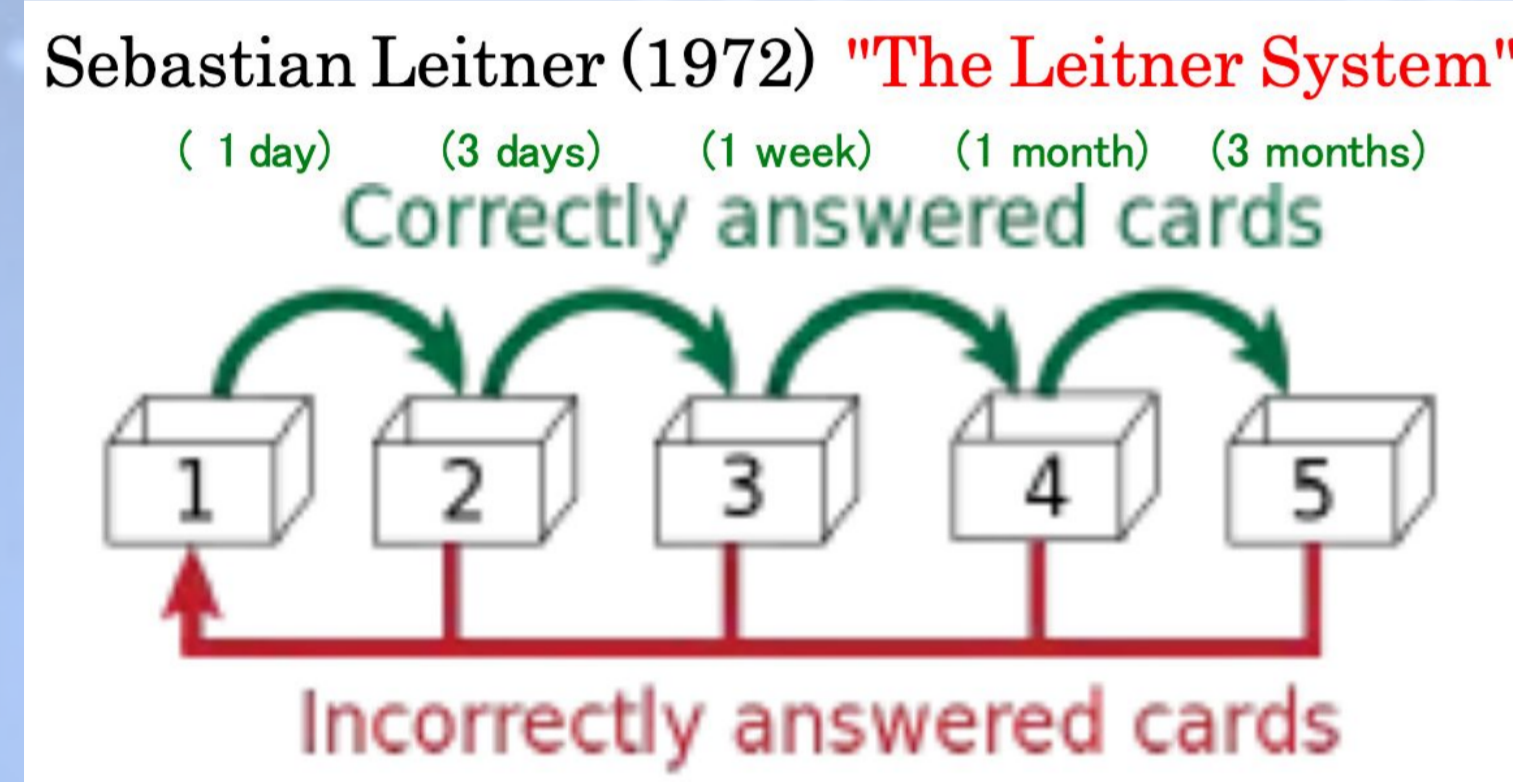
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## ① What is the spacing effect / spaced repetition?



Hermann Ebbinghaus' many discoveries in the late 1800s including the "spacing effect" which accounts for why learners have better memory retention when they engage in spaced learning (multiple but short study sessions) were ground-breaking.

Present day neuroscience has confirmed that spacing repetitions at appropriate intervals allow for enough time for neuro-chemical regeneration to occur which is necessary for establishing and strengthening brain connections (Baddeley, 1990)



The Leitner system takes advantage of the "spacing effect" by utilizing a "learning box" with five compartments (each with a separately scheduled review time) which enables word/study flashcards to move up a compartment when successfully reviewed or go back to the first compartment when unsuccessfully reviewed. Leitner's system became the inspiration or basis for current Spaced Repetition Software (SRS) according to Godwin-Jones (2010).

## ② Which is the best spacing algorithm for learning?

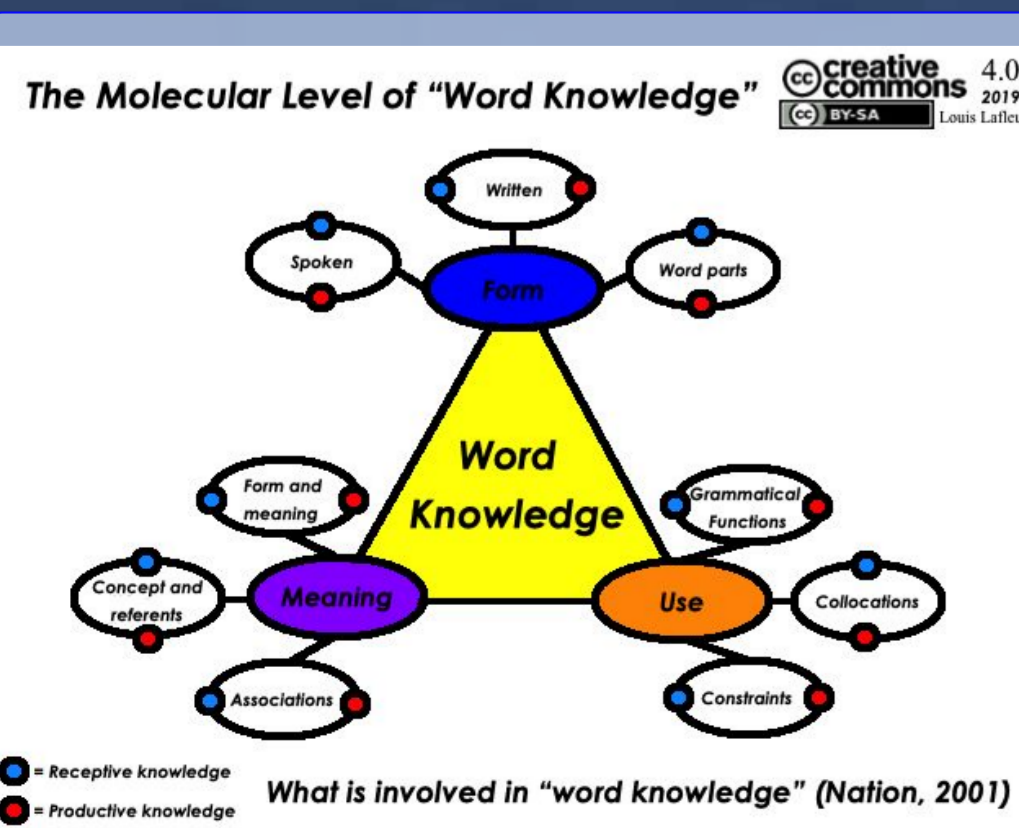
Main Algorithm Types & Intervals	Initial Study	Interval ①	Interval ②	Interval ③	Interval ④
"Expanded" (x type) (-12h start → x 2)	day 1 (start point)	day 1 or 2 (-12 hours)	day 3 (1 day)	day 5 (2 days)	day 9 (4 days)
"Uniform" (same) (→ every 2 days)	day 1 (start point)	day 3 (2 days)	day 5 (2 days)	day 7 (2 days)	day 9 (2 days)
"Massed learning or cramming"	(Total study time compressed into a single session) E.g., If a study session lasts 5 minutes: 5 consecutive sessions x 5 = 25 minutes total				

Most studies find no statistical difference in efficiency between uniform and expanded spacing intervals when tested shortly after their set study periods but longer delayed studies such as Schuetze and Weimer-Stuckmann (2010, 2011) showed that the uniform group outperformed the expanded group at 83% retention versus 59% on a 9-month post-test.

"Expanded" Types & Intervals	Initial Study	Interval ①	Interval ②	Interval ③	Interval ④	Interval ⑤
"Expanded" (+ type) (previous → + 2 days)	day 1 (start point)	day 3 (2 days)	day 7 (4 days)	day 13 (6 days)	day 21 (8 days)	day 31 (10 days)
"Expanded" (x type) (→ x 2)	day 1 (start point)	day 1 (later)	day 3 (2 days)	day 7 (4 days)	day 15 (8 days)	day 31 (16 days)
"Expanded" (a type) (E.g. → -19sec)**	day 1 (start point)	day 1 (19 secs)*	day 1 (6 mins)	day 1 (2 hours)	day 3 (36 hours)	-day 31 (-281 days)

Nevertheless, expanded spacing algorithms: +, x, and a<sup>b</sup> are more practical in handling numerous cards as these can be pushed further back more aggressively in later intervals (→ monthly, etc.). This aids to alleviate the review burden, which permits new cards to be introduced into the study mix more easily. However, there is still no clear master algorithm, and thus more research in this area is required.

## ③ Contributions from Vocabulary Acquisition Research



Nation (2001) has suggested an "in-depth" learning of vocabulary to assure the correct "use" of the words in terms of the output and points to the importance of mastering all three elements/features of word knowledge 1-Meaning 2-Form 3-Use and subsequent 18 aspects of word knowledge.

Schmitt (2008) implied that different teaching approaches may be more beneficial for different stages of word (lexical feature) knowledge as some are mastered earlier than others; therefore focusing on the form-meaning link at first and later enhancing context(use) may prove to be effective.

## ④ What is Indirect or Interleaved Spaced Repetition?

Indirect or Interleaved Spaced Repetition (ISR) combines the concepts of spaced repetition (interval-based study) and task interleaving (the practice of multiple skills or concepts) to promote both long-term and intricate learning (Lafleur, 2020).

In terms of vocabulary learning, task interleaving can provide a wider/deeper range of study, such as, focus on forms, four language skills, both receptive and productive knowledge, and different task flows (L1 to L2, L2 to L1, L2 to L2). ISR does not add extra tasks as additional items/flashcards but cycles between tasks according to the reached interval for every word card or digital word-item flashcard (see figure below).

Tier Q# level	Flow L1 = native language L2 = second language	Task Type	Task/Interval Route : ↓ when recalled/answered successfully ⊖ or ← when recalled/answered unsuccessfully (cooldown timer before next review, h = hour, d = day)		
Meaning Q#1 word or phrase	L2 audio to L1 recall	Recall Check	Session 1 (initial)	Session 7 (6d)	Session 13 (162d)
Meaning Q#2 word or phrase	L1 word/phrase to L2 recall	Recall Check	Session 2 (8h)	Session 8 (9d)	Session 14 (243d)
Form Q#3 word or phrase	L2 audio to L2 word/phrase	Spelling	Session 3 (16h)	Session 9 (18d)	Session 15 (486d)
Form Q#4 sentence	L2 (blank) to L2 sentence	Fill-in-the-blank	Session 4 (1d)	Session 10 (27d)	Session 16 (729d)
Use Q#5 sentence	L2 sentence to L1 sentence	Writing	Session 5 (2d)	Session 11 (54d)	Session 17 (1458d)
Use Q#6 sentence	L1 sentence to L2 sentence	Writing	Session 6 (3d)	Session 12 (81d)	Session 18 (2187d)
(Optional)* Q#7 Text	Reading and Listening (L2 to L2)	(Voiced) Reading	↓ back to top ↑ ↓ back to top ↑ or end (option)		

Aspects of Word Knowledge covered by current ISRS tasks → ○ = mostly △ = possible ✖ = not

Type	Sub-Type	(Nation, 2001) explanation / example	C	ISRS task #
Form	Spoken	R What does the word sound like?	○	1, 2, 3, (5, 6)
		P How is the word pronounced?	△	if 7 is included
	Written	R What does the word look like?	○	2, (3, 4, 6)
Word parts	P How is the word written and spelled?	○	3, 4, 6	
	R What parts are recognizable in the word?	△	if included/highlighted	
Meaning	Form and meaning	R What meaning does this word form signal?	○	1, 5
		P What word form can be used to express this meaning?	○	2, 4, 6
	Concept and referents	R What is included in the concept?	△	if included in WL
Associations	P What items can the concept refer to?	△	if included in WL	
	R What other words does this make us think of?	○	2, 4, 6	
	P What other words could we use instead of this one?	○	2, 4, 6	
Use	Grammatical functions	R In what patterns does the word occur?	○	if covered by 4, 6
		P In what patterns must we use this word?	○	if covered by 4, 6
	Collocations	R What words or types of words occur with this one?	○	4, 6, (5)
Constraints on use (register, frequency...)	P What words or types of words must we use with this one?	○	6	
	R Where, when and how often would we expect to meet this word?	△	4, 6, (5)	
P Where, when and how often can we use this word?	△	6		

R= Receptive, P= Productive, C= Coverage level as judged by author/creator, WL= wordlist, (=) shown with wrong answer

## ⑤ ISRS Research Results

237 Japanese university students utilized the author's ISRS to study the New Academic Word List's word-items (Browne et al., 2013) supplemented with contextualized sentences and translations (Kanazawa & Lafleur, 2019) across two academic semesters (1st semester n=88; 2nd semester n=149). The following results reflect the overall variance in aspects of word knowledge acquisition:

ISRS Task#	[Task Type] Flow	# of Total Responses	% of Total Responses	#Correct Responses	Success %	Difficulty Rank
Q#1	[Recall Check] L2 audio → L1 recall	110092	25.21%	73951	67.17%	4th
Q#2	[Recall Check] L1 word → L2 recall	87896	20.13%	59612	67.82%	5th
Q#3	[Spelling] L2 audio → L2 word	122544	28.07%	30120	24.58%	1st
Q#4	[Fill-the-blank] L2 blank → L2 sentence	76606	17.55%	18885	24.65%	2nd
Q#5	[Writing] L2 sentence → L1 sentence	20183	4.62%	15109	74.86%	6th
Q#6	[Writing] L1 sentence → L2 sentence	19281	4.42%	11409	59.17%	3rd

If all aspects of word knowledge were similar in difficulty, the total number of responses should be highest at Q#1 and decrease onwards according to the common task route. However, ISRS worked as designed and it not only focused review on the more difficult word items but further focused on the more difficult areas/aspects of word knowledge to address each participant's specific learning needs. These results present a strong argument in favor of task interleaving inclusion within spaced repetition systems to promote a deeper learning of vocabulary alongside longer-term retention.

## ⑥ Ongoing / Future Projects

- Ongoing Research/Projects:
- Conducting ISRS research with additional participants
  - Assessing the impact of gamification features on ISRS
  - Adapting a formulaic word list for ISRS use
- Future Research/Projects:
- Test various types of expanded spacing algorithms
  - Utilize an A.I. approach to customize interval times
  - Conduct SRS & ISRS comparative studies
  - Adapt additional word lists for ISRS use
  - A.I. enabled interval skipping/word card selection/deletion

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