

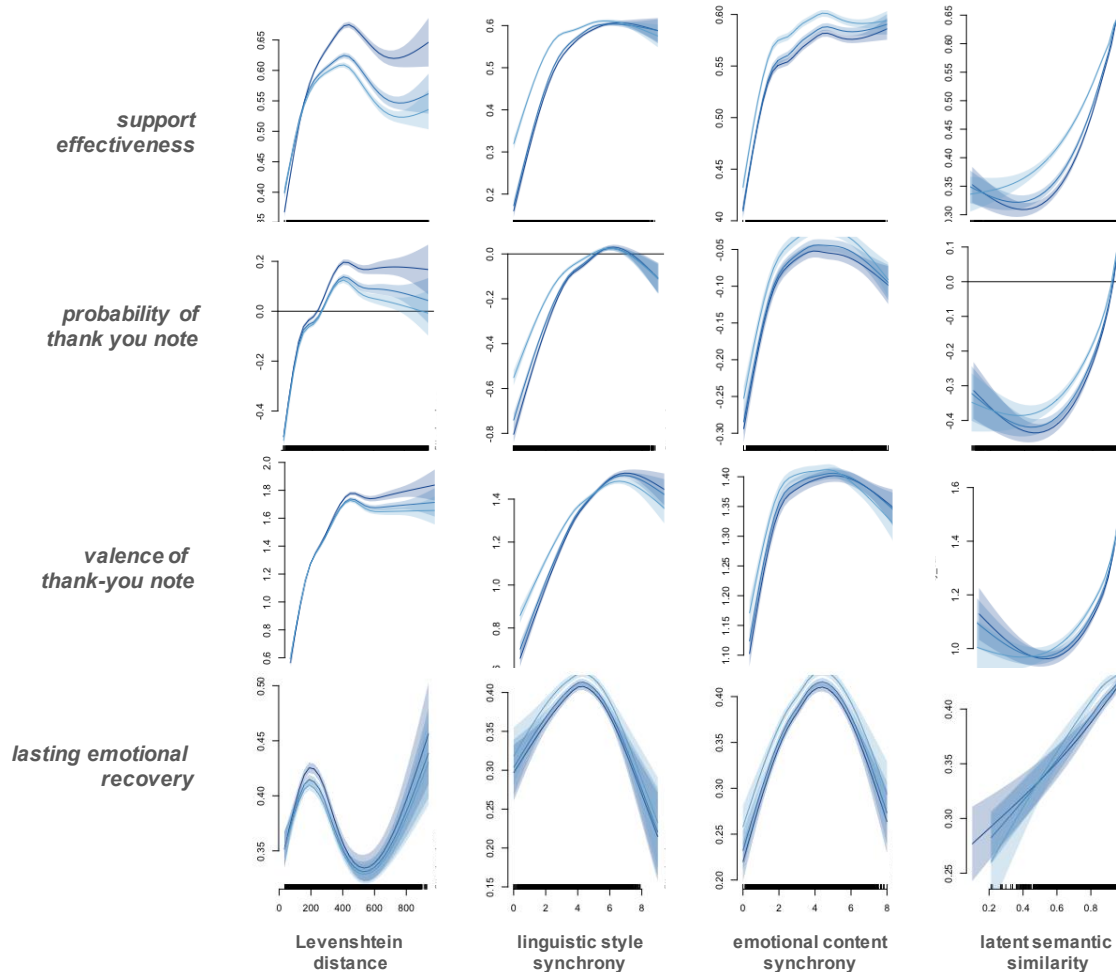
Supplementary Figure S1. Left: Posts describing life stressors and support responses were comparable in length (box- and violin-plot) **Middle:** Support response expressed more positive emotion than stressor posts (box and violin-plot). **Right:** The overall emotional character (i.e., profile of expression of different categories of emotion) of stressor posts and support responses; stressor posts expressed mostly sadness, anticipation, fear, and anger whereas support responses expressed more joy and trust.



Supplementary Figure S3. Use of word categories from the LIWC 2007 dictionary within stressor posts (red) and support responses (blue), as well as grand means of normative data from the LIWC 2007 language manual (asterisks).

Estimating differences in synchrony-outcome relationships across different levels of negation words

To ask how the presence of negation words (e.g., don't, not, shouldn't) in support affected relationships between synchrony and support outcomes, we fit models that used support outcomes as the outcome variable, and included smooth terms for synchrony, proportion of negations, and the interaction of synchrony with proportion of negations as the predictor variables. The interaction term allows us to ask whether the functional form relating a synchrony metric (e.g., latent semantic synchrony) to a support outcome (e.g., emotional recovery) differed at different levels of the proportion of the support response words that were negations (e.g., few negations, an average level of negations, many negations). Results are shown in Supplementary Figure S4. To summarize, magnitudes of the negation by synchrony interactions were subtle – smooth curves relating synchrony to support outcomes differed somewhat in form across low, average, and high levels of negations but these differences were not dramatic.



Supplementary Figure S4 Functions relating synchrony to support outcomes, across texts with different levels of negations. Light blue, medium blue, and dark blue curves (with 95% credibility intervals) reflect model estimates for texts low (25th percentile), average (median), and high (75th percentile) in negations

<i>Metric</i>	1	2	3
1. Levenshtein distance			
2. linguistic style synchrony	-0.06		
3. emotional character synchrony	0.19	0.12	
4. latent semantic similarity	0.32	0.32	0.18

Supplementary Table S1. Different predictor variables were weakly or moderately inter-correlated.

<i>model 1 (support effectiveness)</i>	Eff. df	<i>F</i>	<i>p</i>
Levenshtein distance	6.70	422.60	$<10^{-16}$
linguistic style synchrony	6.28	438.70	$<10^{-16}$
emotional character synchrony	6.70	229.30	$<10^{-16}$
latent semantic similarity	5.95	702.00	$<10^{-16}$
<i>model 2 (thank you note)</i>	Eff. df	Chi sq	<i>p</i>
Levenshtein distance	6.81	1897.50	$<10^{-16}$
linguistic style synchrony	5.66	1831.20	$<10^{-16}$
emotional character synchrony	5.57	422.10	$<10^{-16}$
latent semantic similarity	4.74	2342.70	$<10^{-16}$
<i>model 3 (thank you note valence)</i>	Eff. df	<i>F</i>	<i>p</i>
Levenshtein distance	6.83	786.30	$<10^{-16}$
linguistic style synchrony	5.11	318.40	$<10^{-16}$
emotional character synchrony	5.73	54.10	$<10^{-16}$
latent semantic similarity	5.92	573.30	$<10^{-16}$
<i>model 4 (emotional recovery)</i>	Eff. df	<i>F</i>	<i>p</i>
Levenshtein distance	5.13	38.60	$<10^{-16}$
linguistic style synchrony	3.87	10.50	2×10^{-9}
emotional character synchrony	4.69	36.90	$<10^{-16}$
latent semantic similarity	1.02	9.20	8×10^{-9}
<i>model 5 (support effectiveness)</i>	Eff. df	<i>F</i>	<i>p</i>
response valence	5.98	2461.00	$<10^{-16}$
<i>model 6 (thank you note)</i>	Eff. df	Chi sq	<i>p</i>
response valence	5.90	6232.00	$<10^{-16}$
<i>model 7 (thank you note valence)</i>	Eff. df	<i>F</i>	<i>p</i>
response valence	5.98	3802.00	$<10^{-16}$
<i>model 8 (emotional recovery)</i>	Eff. df	<i>F</i>	<i>p</i>
response valence	4.40	5.20	$<10^{-16}$

Supplementary Table S2. Effective degrees of freedom, F score, and p-values for smooth functions relating Levenshtein distance, linguistic style synchrony, emotional character synchrony, latent semantic similarity, and support response valence predictor variables to effectiveness rating, whether a thank you note was sent, valence of thank you note language, and lasting emotional recovery.

	10 th %ile (0.79)	25 th %ile (0.86)	50 th %ile (0.90)	75 th %ile (0.93)	90 th %ile (0.95)
<i>post</i>	I decided not to travel alone because it's too hard for me. It's too much money and I'm too afraid of feeling alone.	I'm just really tired of everything. I have so much going on and my grades are really slipping. I think I'll fail in life.	My friends are starting to drift away from me, and I have no way of mending things. They'll end up abandoning me.	My mom died ... it's been over a year now but I just can't get over it and I miss her every day. I want to see her again. I don't have my mom anymore.	I think I like this guy, he's cute, but he's also 3 years older than me. Worried that I'll do something embarrassing in front of him.
<i>response</i>	A trip is a once in a lifetime thing because tomorrow is never promised and today is all we have. You do what you need to keep safe, what kind of trip is it?	It could be worse, you could not have any school at all. But I do understand how you are feeling. Just take big breaths.	There's a time in life for everything - break ups, marriages, friends splitting. Remember there's a light at the end of the tunnel and you might get better friends.	I feel the same way. My mom died in 2014 and I have been missing her and wishing to see her again. Don't worry you're not alone. I hope things get better.	If you like him you should ask him out! 3 years isn't that big of a difference. So what if you embarrass yourself. Everyone does embarrassing things!

Supplementary Table S3. Examples of post-response pairs very low (10th percentile), low (25th percentile), average (50th percentile), high (75th percentile), and very high (90th percentile) in latent semantic synchrony.

Directly estimating differences in curves relating latent semantic synchrony versus support response valence to emotional support outcomes

We conducted additional analyses to provide a quantitative comparison of the shape of the curves relating latent semantic synchrony versus support response valence to emotional support outcomes. Specifically, we computed models that estimated factor-smooth interactions (Wood, 2017) asking whether the functional form relating a predictor (here, a standardized score in either latent semantic synchrony or support response valence) to an outcome (here, one of support effectiveness, whether a thank you note was sent, the valence of a thank you note, or a rating of delayed emotional recovery) differed across levels of a factor (an indicator variable for latent semantic synchrony versus support response valence). We used AIC scores to compare the fit of models including the factor-smooth interaction to reduced models including only main effects of the factor and the smooth effect of the standardized scores (Wood, 2017). This procedure yielded clear factor (synchrony versus valence) by smooth (functional form relating the predictor to the outcome) interactions for support effectiveness ratings ($AIC_{fs_ixn}=3639999$; $AIC_{no_ixn}=3643778$), for probability of a thank you note ($AIC_{fs_ixn}=3343269$; $AIC_{no_ixn}=3345660$), for valence of a thank-you note ($AIC_{fs_ixn}=11490476$; $AIC_{no_ixn}=11492877$), and for lasting emotional recovery ($AIC_{fs_ixn}=732812$; $AIC_{no_ixn}=732756$). Overall, these data suggest that the information contained within measures of latent semantic synchrony and support response valence was dramatically different in how it related to immediate and lasting outcomes of the emotional support exchanges.

	AIC
<i>support effectiveness</i>	
reduced	732811.5
interaction	732756.4
<i>thank you note</i>	
reduced	3345660.0
interaction	3343269.0
<i>thank you note valence</i>	
reduced	11492877.0
interaction	11490476.0
<i>delayed emotional recovery</i>	
reduced	732811.5
interaction	732756.4

Supplementary Table S4. AIC scores for models with factor-smooth interactions (versus reduced models omitting the interaction) testing differences in the functional forms relating latent semantic synchrony versus support response valence to social and emotional outcomes.

	correlation with LIWC valence
stressor posts (EmoLex valence)	0.50
support responses (EmoLex valence)	0.37

Supplementary Table S5. Valence of stressor posts estimated with EmoLex was correlated 0.50 with valence of support responses estimated with LIWC. Valence of support responses estimated with EmoLex was correlated 0.37 with valence of support responses estimated with LIWC.

category	current data		LIWC 2007 normative data						grand mean
	posts	responses	emotion	control	science	blogs	novels	talking	
FUNCTION									
WORDS	57.5	83.5	63.9	57.5	34.7	55.3	57.2	60.5	54.9
TOTAL PRON	31.5	31.0	20.2	14.3	3.2	16.1	14.9	21.5	15.0
PERSONAL PRON	21.3	22.5	14.2	10.8	0.8	10.7	10.3	13.6	10.1
1ST SINGULAR	16.1	4.8	10.4	8.5	0.1	6.4	2.6	6.3	5.7
1ST PLURAL	0.6	0.4	0.7	0.9	0.4	0.9	0.6	1.1	0.8
TOTAL 2ND	0.2	10.5	0.4	0.2	0.0	1.2	1.3	3.9	1.2
3RD SINGULAR	3.9	3.9	2.0	0.7	0.0	1.5	4.9	1.5	1.8
3RD PLURAL	0.7	1.7	0.7	0.4	0.3	0.7	1.0	0.8	0.7
IMPERSONAL PRON	5.4	10.8	6.0	3.5	2.4	5.4	4.6	7.9	5.0
ARTICLES	3.3	5.2	5.0	6.6	7.7	5.9	8.2	4.4	6.3
COMMON VERBS	25.2	31.0	17.4	13.6	5.0	14.6	13.0	19.9	13.9
AUXILIARY VERBS	14.6	18.7	10.7	7.4	3.9	8.8	7.8	12.4	8.5
PAST TENSE	5.5	2.0	5.8	4.6	1.5	3.8	6.3	4.0	4.3
PRESENT TENSE	17.1	22.3	9.2	6.7	2.7	8.7	4.6	14.0	7.6
FUTURE TENSE	1.5	3.3	1.1	1.5	0.4	1.1	1.1	1.0	1.0
ADVERBS	5.9	8.6	6.3	4.5	1.4	5.5	3.8	6.2	4.6
PREPOSITIONS	10.6	16.0	12.9	16.1	12.9	12.1	14.1	9.3	12.9
CONJUNCTIONS	9.1	12.3	7.4	7.7	4.3	6.4	6.7	5.7	6.4
NEGATIONS	6.7	4.7	2.2	0.8	0.4	1.8	1.7	2.9	1.7
QUANTIFIERS	2.8	3.9	3.1	2.5	1.9	2.8	2.3	2.2	2.5
NUMBERS	0.7	0.8	1.3	2.7	7.1	2.0	1.2	2.0	2.7
SWEAR WORDS	0.4	0.3	0.1	0.0	0.0	0.3	0.1	0.4	0.2
SOCAL	16.2	28.4	9.1	5.6	2.6	8.7	12.3	11.8	8.3
FAMILY	0.9	0.7	1.0	0.3	0.1	0.4	0.4	0.2	0.4
FRIENDS	1.7	1.3	0.5	0.4	0.0	0.3	0.2	0.2	0.3
HUMANS	1.5	2.0	0.8	0.4	0.2	0.8	1.1	0.8	0.7
AFFECTIVE	11.0	14.7	6.0	2.6	2.2	5.8	4.9	4.9	4.4
POSITIVE	4.6	9.9	3.3	1.8	1.3	3.7	2.9	3.4	2.7
NEGATIVE	5.3	4.0	2.7	0.7	0.8	2.1	2.0	1.5	1.6
ANXIETY	1.1	0.9	0.7	0.2	0.2	0.3	0.4	0.2	0.3
ANGER	1.6	0.9	0.7	0.1	0.1	0.8	0.6	0.6	0.5
SADNESS	1.9	1.0	0.6	0.1	0.3	0.4	0.6	0.2	0.4
COGNITIVE	26.7	32.4	19.7	14.4	11.3	16.0	15.2	15.7	15.4
INSIGHT	6.3	5.2	3.3	1.3	1.8	2.2	2.0	2.3	2.2
CAUSATION	1.9	2.4	1.9	1.3	2.2	1.4	1.0	1.6	1.6
DISCREPANCY	2.6	5.0	2.1	1.1	0.5	1.5	1.5	1.7	1.4
TENTATIVENESS	3.0	7.0	2.9	2.3	1.3	2.7	2.2	2.4	2.3
CERTAINTY	1.8	2.5	1.7	0.8	0.6	1.4	1.4	1.3	1.2
INHIBITION	0.6	0.9	0.5	0.4	0.6	0.5	0.6	0.4	0.5

INCLUSION	6.7	6.4	5.1	6.4	4.1	4.7	5.4	3.9	4.9
EXCLUSION	5.0	7.3	3.5	1.7	0.9	2.8	2.2	3.3	2.4
PERCEPTUAL	2.7	3.2	2.1	1.9	1.2	2.3	3.3	2.3	2.2
SEEING	0.5	0.8	0.5	0.8	0.7	0.9	1.3	1.0	0.9
HEARING	0.6	0.7	0.4	0.4	0.1	0.7	1.2	0.7	0.6
FEELING	1.5	1.6	1.0	0.6	0.2	0.6	0.7	0.5	0.6
BIOLOGICAL	2.3	2.3	2.0	3.0	1.0	2.1	2.1	1.5	1.9
BODY	0.5	0.4	0.5	1.1	0.3	0.8	1.2	0.6	0.7
HEALTH	0.8	0.8	0.9	0.5	0.6	0.5	0.4	0.3	0.6
SEXUAL	1.1	1.1	0.3	0.1	0.1	0.4	0.2	0.3	0.2
INGESTION	0.3	0.2	0.3	1.4	0.2	0.4	0.4	0.4	0.5
RELATIVITY	14.7	14.2	13.8	20.1	10.2	13.8	13.9	12.8	14.1
MOTION	1.8	2.2	2.1	3.6	1.2	2.1	2.2	2.7	2.3
SPACE	5.2	6.0	5.4	7.9	6.1	5.6	6.8	5.5	6.2
TIME	6.4	5.2	6.0	8.2	2.7	5.7	4.7	4.3	5.3
WORK	1.2	1.3	2.1	3.7	1.7	1.7	1.0	1.7	2.0
ACHIEVEMENT	1.8	3.4	1.6	1.5	1.6	1.5	1.1	1.0	1.4
LEISURE	0.6	0.8	0.8	1.9	0.4	1.6	0.7	1.0	1.1
HOME	0.3	0.3	0.6	1.9	0.1	0.5	0.6	0.4	0.7
MONEY	0.2	0.4	0.3	0.6	0.4	0.6	0.5	0.6	0.5
RELIGION	0.1	0.3	0.2	0.2	0.1	0.3	0.4	0.2	0.2
DEATH	4.7	2.0	0.2	0.0	0.1	0.2	0.2	0.1	0.1
ASSENT	6.6	19.4	0.1	0.1	0.1	0.6	0.2	3.6	0.8
NON-FLUENCIES	5.0	8.2	0.2	0.1	0.1	0.3	0.1	0.7	0.3
FILLERS	0.1	0.1	0.0	0.0	0.0	0.0	0.0	1.2	0.2
AllPunc	13.4	13.6	12.2	12.9	33.9	23.8	22.1	49.4	25.7
Period	4.4	5.6	6.1	6.6	11.7	10.7	5.5	9.8	8.4
Comma	1.1	2.1	2.9	3.2	7.6	4.1	7.4	5.1	5.1
Colon	2.8	0.2	0.1	0.6	0.2	0.7	0.2	0.1	0.3
SemiC	0.0	0.1	0.0	0.0	0.4	0.1	0.6	0.1	0.2
QMark	0.1	0.3	0.2	0.0	0.1	0.6	0.6	2.3	0.6
Exclam	0.2	0.8	0.1	0.1	0.0	1.3	0.5	0.2	0.4
Dash	0.1	0.1	0.3	0.5	2.5	1.1	1.6	0.8	1.1
Quote	4.4	3.8	0.3	0.2	0.2	0.7	3.4	0.2	0.8
Apostro	4.2	3.7	1.7	1.0	0.2	2.4	2.1	3.8	1.9
Parenth	NA	NA	0.2	0.2	4.9	0.5	0.1	0.0	1.0
OtherP	13.1	13.1	0.2	0.3	1.3	1.1	0.1	27.1	5.0

Supplementary Table S6. Use of all word categories from the LIWC 2007 dictionary, along with normative data described in the LIWC 2007 language manual. Numbers reflect the percentage of the words in a given text that belong to the category.

Accounting for variation in the time elapsed between support receipt and the rating of emotional recovery

Because emotions can change over time, we conducted additional analyses that estimated effects of synchrony while accounting for the variability in the amount of time elapsed from when participants received emotional support messages to when they made a rating of their emotional recovery. The median time to rating was 63min, with an interquartile range of 40min to 8h, and time to rating showed less than .001% shared variance with any of the synchrony measures. In order to account for variation in time, we fit a model with delayed emotional recovery ratings as an outcome variable and smooth functions of surface-level textual synchrony, linguistic style synchrony, emotional content, latent semantic synchrony, and time to rating as predictor variables. The estimated functional forms relating each type of synchrony to emotional recovery ratings were significantly different from zero (i.e., a flat line) and substantively the same in functional form as those estimated from models that omitted the effect of time (reported in the main manuscript).

Application script

The following script represents the application flow experienced by users of the Koko application including: onboarding, composing a post, learning to respond to the posts of others, composing a response, receiving a response, and providing an emotional recovery assessment. Across all these stages, the application (“Kokobot”) guides the user with text-based messages about how to proceed.

Anyone can interact with the current implementation of the application, which can be accessed by opening chat.itskoko.com in a web browser. Note that changes have been made to the application since the data described in this paper were collected.

ONBOARDING

Koko: Hi, I'm KokoBot ☐

I help people when they're struggling...

User [Button Response]:

- **Cool, but how?**

Koko: Well, I can connect you to a huge network of people from around the world ☐ They'll help you find hope and see the bright side of things.

You can really open up here. Here's a post someone just wrote:

"My best friend never texts me back anymore. All my friends leave me. No one cares about me at all."

User [Button Response]:

- **OK, I read this**

Koko: See how there isn't a name attached to the post? That's because things are anonymous

User [Button Response]:

- □

Koko: And you won't find any bullies or trolls □□ - so you can open up. I review everything to make sure it's a safe space.

User [Button Response]:

- **Nice**

Koko: Also, it's important to know that Koko isn't for crisis situations □ We'll send you more help if it looks like you need it

User [Button Response]:

- **That's good to know**

Koko: OK, let's post something!

COMPOSING A POST

Koko: First, describe a situation that's bothering you and I'll send it out. (Be specific, 3 sentences max!)

User: *I've been studying more and more, but it doesnt help. I keep failing over and over.*

Koko: Now, what's your most negative take on this? What is the darkest thought you have about this? What goes through your mind? (1 sentence max, please)

User: *The teacher hates me and I'm going to end up flunking out.*

Koko: OK, now do the opposite. What's your most positive take on this? ☀️
What's a bright side to this? (If you can't think of anything, just make something up!)

User: I probably won't fail completely. Maybe i can get some help

LEARNING TO RESPOND

Koko: OK, thanks for sharing all that. □ sending this off to the Koko community... You should start getting replies in a few minutes. While you wait, let's try helping others.

User [Button Response]:

- **Let's do it** ☐

Koko: OK, here's how it works... On Koko, we help people see the bright side to things 🌤️ We don't just tell people what to do. Here's a quick example... Imagine someone you're dating stops texting for a few days. Check out this reply:

"You should just dump him if he's not texting you. Just tell him he sucks. "

How would you rate this reply?

User [Button Response]:

- ☐ Looks Good
- ☐ **Needs work...**

Koko: I agree ☐ This is just telling the person what to do. Replies should always say something nice ☐ Here's another one:

"Sorry to hear this ☐... It sucks, but it's normal to feel like that. Sometimes people get busy or distracted or their phones die. You can't know for sure. If they're ignoring you on purpose, they might not deserve you!"

What do you think of this?

User [Button Response]:

- ☐ **Looks Good**
- ☐ Needs work...

Koko: YES! ☐☐☐ This response is caring. It respects the person's feelings. And best of all? It gives a brighter perspective ☐

Replies that look on the bright side make people feel the best. And they get the most thank yous ☐

Ok, ready to make a real reply?

User [Button Response]:

- ☐ Yea!

COMPOSING A RESPONSE

Koko: Someone wrote:

I'm about to give a talk. I prepared for weeks and I think I know what to say but I'm still really, really nervous.

Their most negative thought is:

My voice is going to shake and people will know I'm nervous. They will all think I'm dumb.

Want to help rethink this?

User [Button Response]:

- ☐ Yes
- ☐ Skip
- ☐ Flag
- ☐ Exit

Koko: OK, what's a more positive 🐾take on this situation? (No more than 5 sentences!) Reply or select the help option below ☐

User [Button Response]:

- **Gimme some hints**

Koko: Try not to just give advice ☐

- Avoid just saying things like, 'just dump him', or 'tell the teacher'
- Instead, help this person think more positively 🐾
- Could something good come from this? ☐
- Is this person being too hard on themselves? ☐
- Write your reply below ☐

User: *I've been there. Giving talks is HARD. But you'll be more aware of your nerves than anyone, trust me. And being nervous can be good. It focuses you for success. If anyone knows you're nervous, it's probably because they've felt nervous before too. They'll know you really care about what your saying. I hope it goes well.*

Koko: Looks great! ☐ sending this off..."

RECEIVING A RESPONSE

Koko: Someone replied to your post! ☐ ☐

User [Button Response]:

- **Let's check it out**

Koko: You wrote:

I've been studying more and more, but it doesn't help. I keep failing over and over. The teacher hates me and I'm going to end up flunking out.

Someone replied :

Sorry to hear this ☐ It's hard to feel like you aren't getting better. Sometimes the way we learn is that we struggle and struggle and then all of a sudden we get much better. It's not always gradual, so hang in there, ask for help, and be kind to yourself. No one is good at everything all the time, i know I'm not!

What do you think of this reply? Your answer will be hidden, so be honest!

User [Button Response]:

- ☐ **It's really good...**
- ☐ It's ok...
- ☐ It's really bad...

Koko: Cool! Want to send this person a thank you note?

User [Button Response]:

- ☐ **Yes**
- Nope

Koko: Tell me what you liked best about the reply and I'll pass it along! ☐

User: *Thank you so much! This is really encouraging actually and it's nice to know I'm not alone in feeling this way.*

EMOTIONAL RECOVERY ASSESSMENT

Koko: Hey, I just want to follow up on your recent post...

User [Button Response]:

- **Sure**
- No Thanks

Koko: You wrote: "I just got fired. I feel humiliated and worthless. This is a total surprise. I'm a loser."

User [Button Response]:

- **Yes, I remember**

Koko: Now that you've gotten some replies, how do you feel about this situation?

User [Button Response]:

- ☒ **Better**
- ☐ About the same
- ☐ Worse

Koko: Awesome! ☺☺☺ It's good to hear that!