

The sense of agency can be modulated by the interaction between action optionality and valence of outcomes

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Background

◎ Sense of agency

... a feeling of control over one's actions to cause sensory events in the environment (Moore & Obhi, 2012)

According to previous researches...

- (1) The more number of action alternatives one has, the more strongly sense of agency he / she feels (Barlas & Obhi, 2013)
- (2) Negative emotional outcomes attenuate sense of agency (Yoshie & Haggard, 2013)

➔ Does the interaction between action optionality and valence of outcomes modulate sense of agency?

Method

[Participants] 25 right handed participants (10 women, mean age = 22.8 ± 1.88)

[Stimuli] 4 each positive and negative non-verbal emotional vocalization stimulus from IADS-2. Each sound was trimmed to 700ms duration.

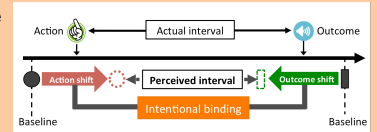
◎ Intentional Binding (Haggard et al., 2002 ; "I.B." from now on)

subjective compression of the temporal interval between a voluntary action and its external sensory consequence
The size of I.B. effect depends on a perceived causal relationship between one's action and its outcome.

➔ implicit measure of sense of agency

In experimental measurement :

the difference between **baseline** (perceived timing of action or stimuli presentation occurring **independently**) and **operant condition** (that when action is **followed** by stimuli presentation) .



Action Optionality (two levels)

- **Choice :**
Choice the one of 7 keys and press
- **No Choice :**
Press the middle one of 7 keys only through the brock

Valence / Arousal of Outcomes

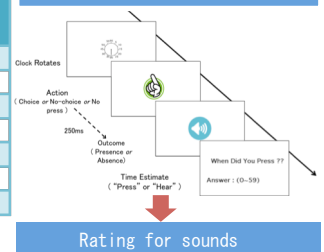
- **Score ranging from 1 to 9 for each sound** rated by each participant after the I.B. task

- ✓ I.B. task consists of 3 baseline & 4 operant brocks.
- * Action optionality was consistent through brocks.
- * In randomized order, each of 8 sounds was presented 4 times within a brock.

Exp. Brock	Action (Key press)	Outcome (Sound)	Estimation Event	Number of trials
A	Choice	Present	Action	32x2
B	Choice	Present	Outcome	32x2
C	Choice	-	Action	32
D	No choice	Present	Action	32x2
E	No choice	Present	Outcome	32x2
F	No choice	-	Action	32
G	-	Present	Outcome	32x2

* Brock C · F = Action baseline, Brock G = Outcome baseline

Intentional binding (IB) task



Result

Analysis by Linear Mixed Model with ML ~ Action shift / Outcome shift / Overall binding

Explanatory variable : rating score of Valence and Arousal(as covariance) for each sound by each participant / Action optionality (dummy variable)

Response variable : Binding effect (ms)

Random effect : (1 |sub)+(1 |sub:valence)+(1 |sub:Arousal)+(1 |sub:Choice)

- ➔ Arousal was eliminated from models of overall binding and action shift because of no contribution to fitness (tested with likelihood ratio test).

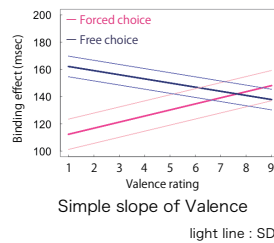
[Overall binding]

There was a significant interaction effect of Valence and Choice.

	Estimate (SE)	df	t value	P value
(Intercept)	127.27 (17.58)	35.40	7.24	< 0.01
Valence	4.46 (2.24)	187.91	1.99	< 0.05
Choice	24.76 (15.85)	23.99	1.56	0.13
Valence : Choice	-7.50 (2.75)	205.41	-2.72	< 0.01

The result of simple slope test showed Valence of outcomes modulated binding effect only when action was chosen by participants.

Binding effect in free choice condition was higher than no choice condition when outcomes were more positive.



[Action shift]

There was a significant main effect of Valence.

More positive outcomes induced larger action shifts.

	Estimate (SE)	df	t value	P value
(Intercept)	16.17 (7.77)	42.83	2.08	< 0.05
Valence	2.40 (1.21)	218.5	1.98	< 0.05
Choice	11.40 (8.91)	24	1.28	0.21
Valence : Choice	-1 (1.52)	260.75	-0.65	0.51

[Outcome shift]

There were significant main effect of Arousal and interaction effect of Valence and Choice.

Simple slope test showed a similar result to that in overall binding.

	Estimate (SE)	df	t value	P value
(Intercept)	118.45 (14.83)	23.94	7.99	< 0.01
Valence	-1.56 (1.40)	61.80	-1.12	0.47
Choice	13.90 (13.45)	23.98	1.03	0.31
Arousal	-4.15 (2.08)	92.45	-2.00	< 0.05
Valence : Choice	-6.22 (2.23)	204.90	-2.72	< 0.01

Conclusion

- ✓ We found **the interaction effect between action optionality and valence of outcomes** on intentional binding.

- ☆ Negative emotional outcome *increased* binding effect only when it was caused by an action chosen by oneself.

- ☆ When more positive outcome was presented, free action selection induced larger binding effect than no choice condition.

- ➔ Man more strongly feels sense of agency on negative outcomes caused by their choice (➔ a link to responsibility ?)

- ➔ Those results are also the first evidence of interaction of prospective and retrospective cues of sense of agency.

- ? The interaction effect was found only in "outcome shift" but not in "action shift".

- ➔ There is a possibility the two sides of binding effects have different mechanisms, specifically in terms of the information integration.