Grasping that One Thing is Related to Another: Contributions of Spatial Contiguity, Temporal Proximity, and Physical Connection

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What enables infants to learn the relation between a stimulus and its associated reward?

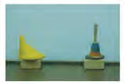
STANDARD CONDITION

Delayed Nonmatching to Sample Task (DNMS)

The subject (S) is presented with a sample stimulus that sits atop a shallow well containing a reward.

S is encouraged to pick up the stimulus to reveal the reward.

S retrieves the reward from the well.



A delay is imposed (e.g. 5 sec) and then S is presented with the sample stimulus paired with a novel object.

The reward is always under the new, nonmatching stimulus on each trial.

S retrieves the reward from the well.

No stimulus is ever used more than once.

Infants of 9-12 months fail the standard DNMS task (Diamond *et al.*, 1994).

Infants cannot succeed until 20-21 months (Diamond *et al.*, 1994; Overman *et al.*, 1992).

The performance of infants on standard DNMS resembles that of:
- **AUTISTIC** children (Dawson *et al.*, in press) AND
  - monkeys with lesions of **VENTROLATERAL PREFRONTAL CORTEX** (Kowalska *et al.*, 1991; Rushworth *et al.*, 1997)

All 3 groups fail for a reason other than memory:
- they have extreme difficulty with the task, and many are utterly unable to succeed, even with the briefest of delays, or no delay at all.
- for those who eventually succeed, their performance remains excellent even at long delays; their performance is insensitive to the length of delay.

This poster addresses why young infants are unable to succeed on the DNMS task.

VELCRO CONDITION

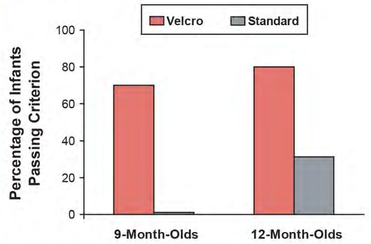
Differed from Standard Condition in that here **the reward was connected to the base of the stimulus.**

The stimuli were atop the wells and the rewards were concealed within the wells, just as in the Standard DNMS Condition.

However, here, instead of remaining in the well when a stimulus was displaced, the reward moved with the stimulus.

The reward was detachable from the base of the stimulus and was retrieved by the infant.

After a 5-sec delay, the sample and novel stimuli were presented, with the reward velcroed to the base of the novel stimulus, concealed within the well.



Infants of 9-12 months SUCCEED. (Diamond *et al.*, 1999)

Jarvik (1956) found something similar with chimpanzees.

It takes chimpanzees 100 or more trials to learn a simple color discrimination task (e.g., red plaque over one well, blue plaque over the other; position of plaques randomly varied over trials; reward always in well under the red plaque).

However, when Jarvik made one simple change -- sticking the peanut reward to the underside of the plaque -- chimpanzees learned this same discrimination after only one trial.

Are infants able to succeed in the Velcro Condition because of...

...the spatial proximity of stimulus and reward?

...the close temporal proximity of acting on the stimulus and seeing the reward?

...the physical connection between stimulus and reward?

JACK-IN-THE-BOX CONDITION

The reward was **temporally close**, but **spatially displaced** from the stimulus.

Stimulus and reward appeared to be **physically connected** because it appeared as if the stimulus were part of a lever, that when pulled, made the jack in-the-box pop up.

Differed from the Standard Condition in that:

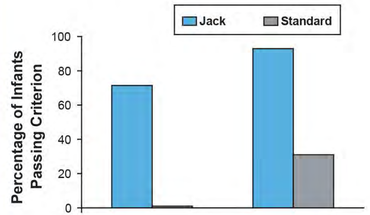
Reward popped up immediately after stimulus was displaced (reward seen closer in time to acting on the stimulus than in Standard).

Reward was located 12.5 cm behind stimulus stimulus (stimulus and reward more spatially separated here).

The stimuli sat atop the jack-in-the-box apparatus. The rewards were concealed within the apparatus.

When a stimulus was discplaced, the jack-in-the-box puppet popped up immediately.

After a 5-sec delay, the sample and novel stimuli were presented; only the puppet behind the novel stimulus was able to pop up.



Infants of 9-12 months SUCCEED. (Diamond & Lee, submitted)

The Jack-in-the-Box Condition eliminated spatial proximity as the critical variable. The reward was more spatially separated here than in the Standard Condition, yet 9- & 12-month-olds succeeded. We investigated in the present study whether temporal proximity or physical connection between stimulus and reward were key to infants being able to grasp the relation between stimulus and reward.

HINGE CONDITION

The reward was **temporally close**, but **not physically connected** to the stimulus, **nor spatially close** to the stimulus.

Differed from the Standard Condition in that:

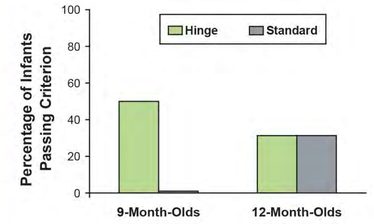
Reward sat in a well directly behind the stimulus (instead of directly below) and was seen immediately after the stimulus was moved.

The blocks containing the wells sat vertically, rather than horizontally. The stimuli were attached to the lids of the wells.

The act of trying to retrieve a stimulus caused the lid in front of the well to open.

Since the lid and stimulus swung down, the stimulus was removed from view and the reward was revealed immediately.

After a 5-sec delay, the sample and novel stimuli were presented, with the reward concealed behind the novel stimulus.



Infants of 9-12 months FAIL.

Subjects Tested

32 infants were tested in the Hinge Condition:
16 infants (8 M, 8 F) at 9 months.
16 infants (8 M, 8 F) at 12 months.
All infants were full-term and healthy. Most were of European Caucasian descent and had middle-class, college-educated parents.

STRING CONDITION

The reward was **physically connected**, but **not temporally close** to the stimulus, **nor spatially close** to the stimulus.

Differed from the Standard Condition in that:

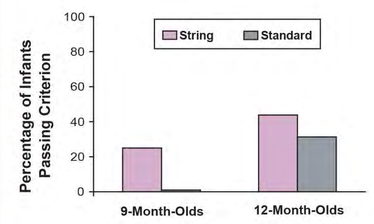
The reward was connected to the base of the stimulus by an 8.5 cm long string.

The stimuli sat atop the wells and the rewards were concealed within the wells.

When the stimulus was lifted, either the reward followed it, dangling below from its string, or the reward remained in the well with the string connecting the stimulus and reward remaining visible.

The reward was detachable from the string and was retrieved by the infant.

After a 5-sec delay, the sample and novel stimuli were presented, with the reward concealed beneath the novel stimulus.



Infants of 9-12 months FAIL.

Subjects Tested

32 infants were tested in the String Condition:
16 infants (8 M, 8 F) at 9 months.
16 infants (8 M, 8 F) at 12 months.
All infants were full-term and healthy. Most were of European Caucasian descent and had middle-class, college-educated parents.

SUMMARY

	SPATIALLY CLOSE	TEMPORALLY CLOSE	APPEARS PHYSICALLY CONNECTED	PERFORMANCE AT 9-12 MONTHS
STANDARD	no	no	no	POOR

Results from the Standard Condition show that when spatial proximity, temporal proximity, and physical connection are all absent, infants of 9-12 months fail.

VELCRO	✓	✓	✓	GOOD

Results from the Velcro Condition show that when spatial proximity, temporal proximity, and physical connection are all present, infants of 9-12 months succeed.

JACK	no	✓	✓	GOOD

Results from the Jack-in-the-Box Condition show that spatial proximity is not needed for infants of 9-12 months to succeed.

HINGE	no	✓	no	POOR

Results from the Hinge Condition show that temporal proximity alone is not sufficient for infants of 9-12 months to succeed.

STRING	no	no	✓	POOR

Results from the String Condition show that physical connection alone is not sufficient for infants of 9-12 months to succeed.

CONCLUSIONS

The conjunction of temporal proximity and a physical connection appears to be necessary for infants of 9-12 months to grasp the relation between a stimulus and its associated reward.

Spatial proximity is not needed.
Neither temporal proximity alone nor physical connection alone is sufficient. Both are needed.

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