Les mécanismes d'analogie chez le babouin

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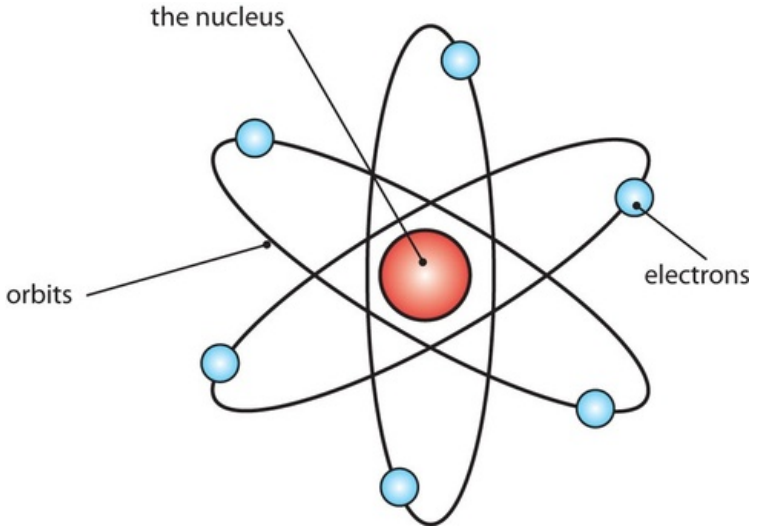
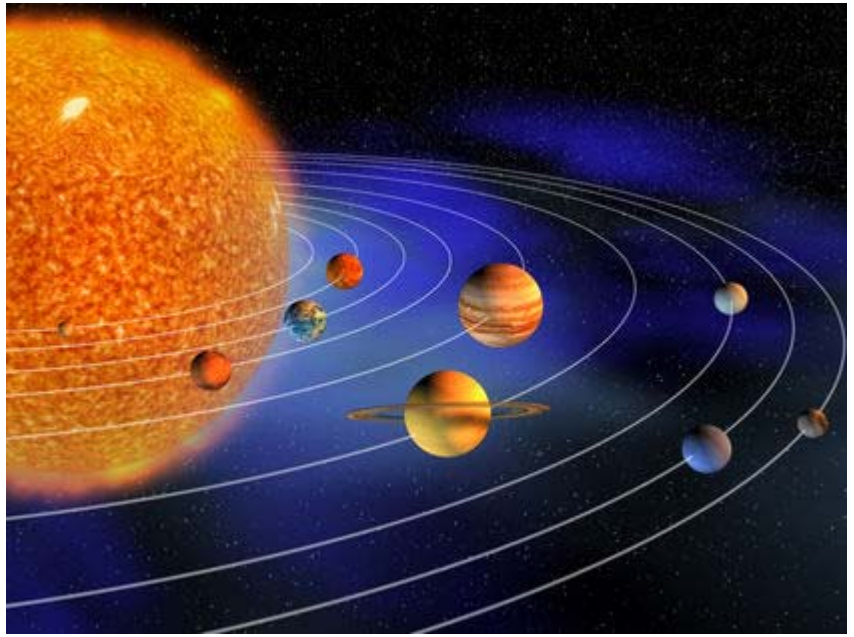
L’analogie de Rutherford



« La structure de l’atome ressemble à celle du système solaire »



Système solaire

Atome

Planètes

Relations de premier ordre

Soleil

Relations entre des relations

Electrons

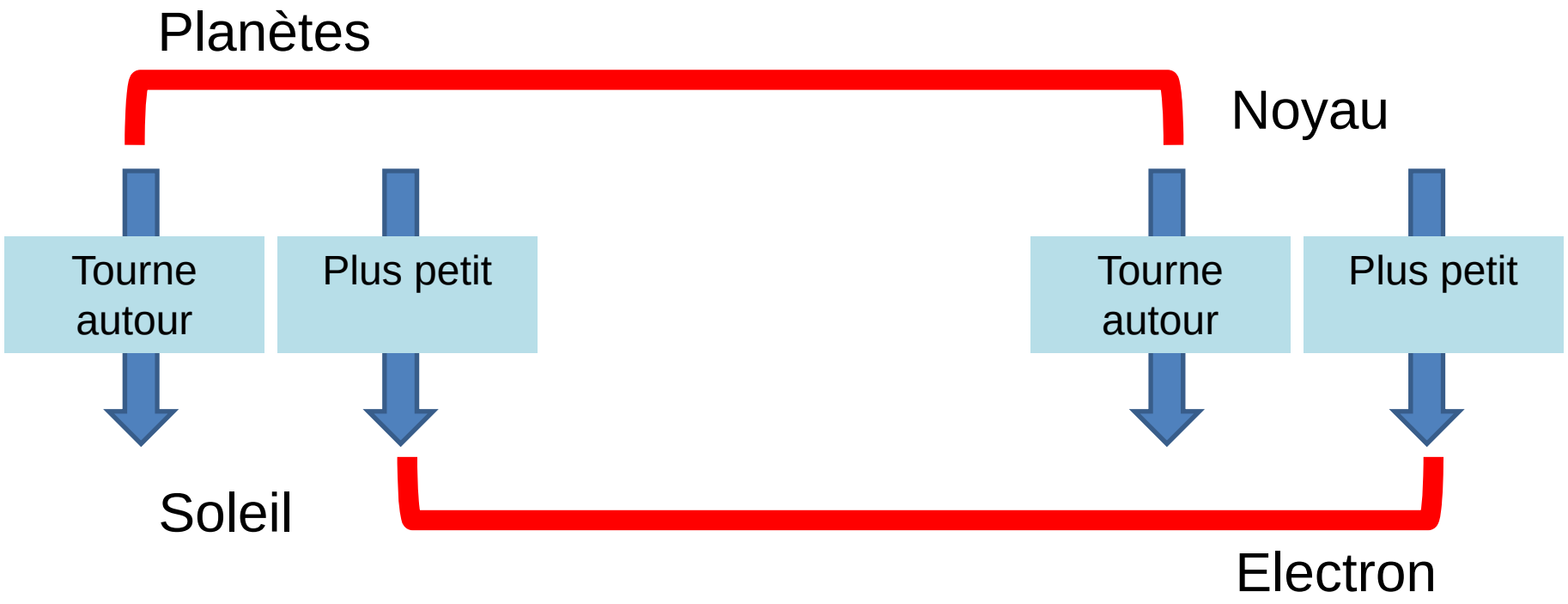
Relations de premier ordre

Noyau

Domaine source

Domaine cible

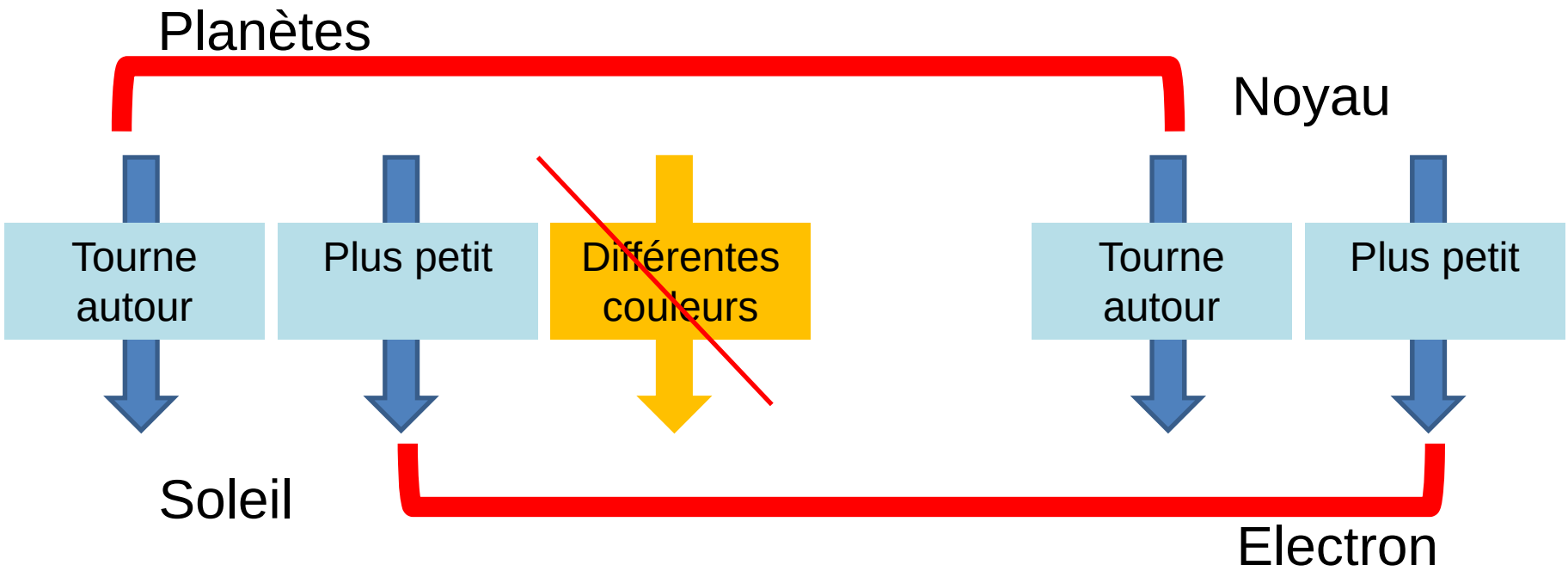
Mise en correspondance



Domaine source

Domaine cible

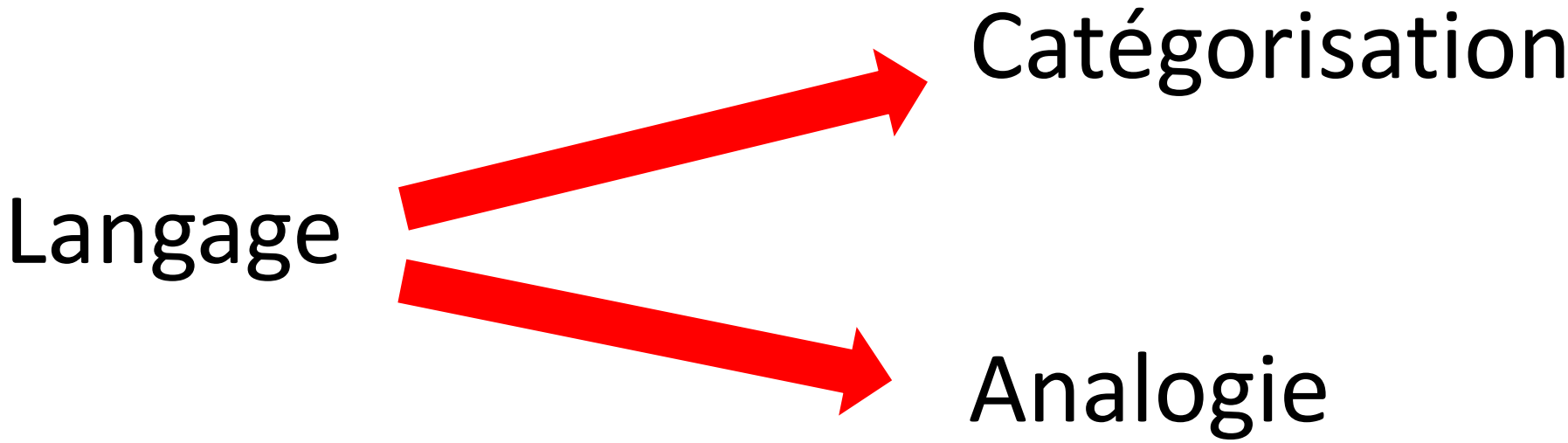
Plusieurs relations de 1er ordre



Domaine source

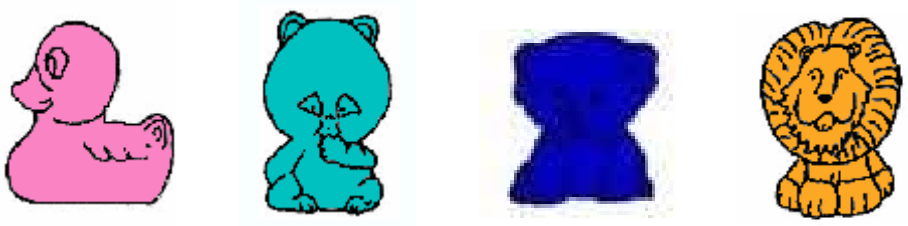
Domaine cible

L’analogie : phénomène de catégorisation

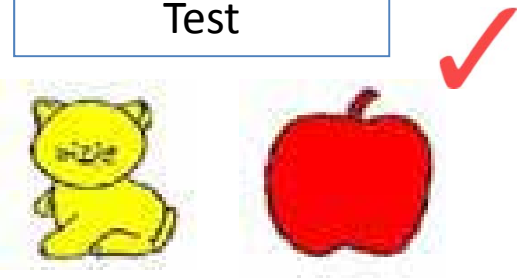


Catégorisation et langage

Familiarisation



Test



Condition	**Stimulus**	**Categorisation?**
“No Word”	“Look at this…”, etc.	Non
“Word (variable)”	“This is *a toma*”…this is a *blicket*”, etc.	Non
« Melodies »	♫♫♫♫♫	Non
“Word (consistent)”	“This is a *toma…this is a toma”, etc.*	Oui

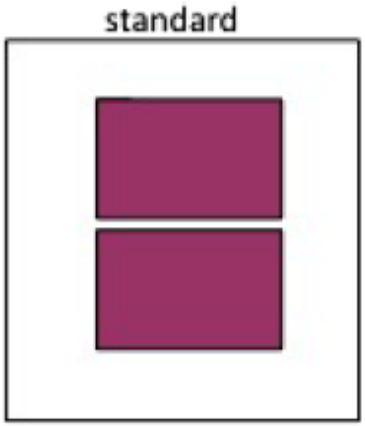
Age: 6 à 12 mois

Waxman & Gelman, TICS (2009)

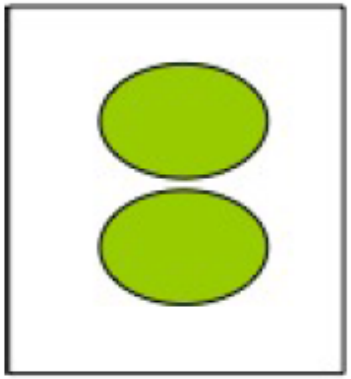
L’acquisition des mots (langage) « invite » à la catégorisation

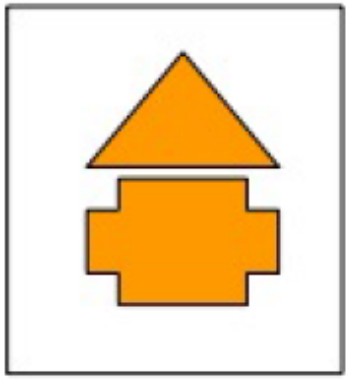
Raisonnement analogique et langage

Which of these two pictures is more like the first one ?

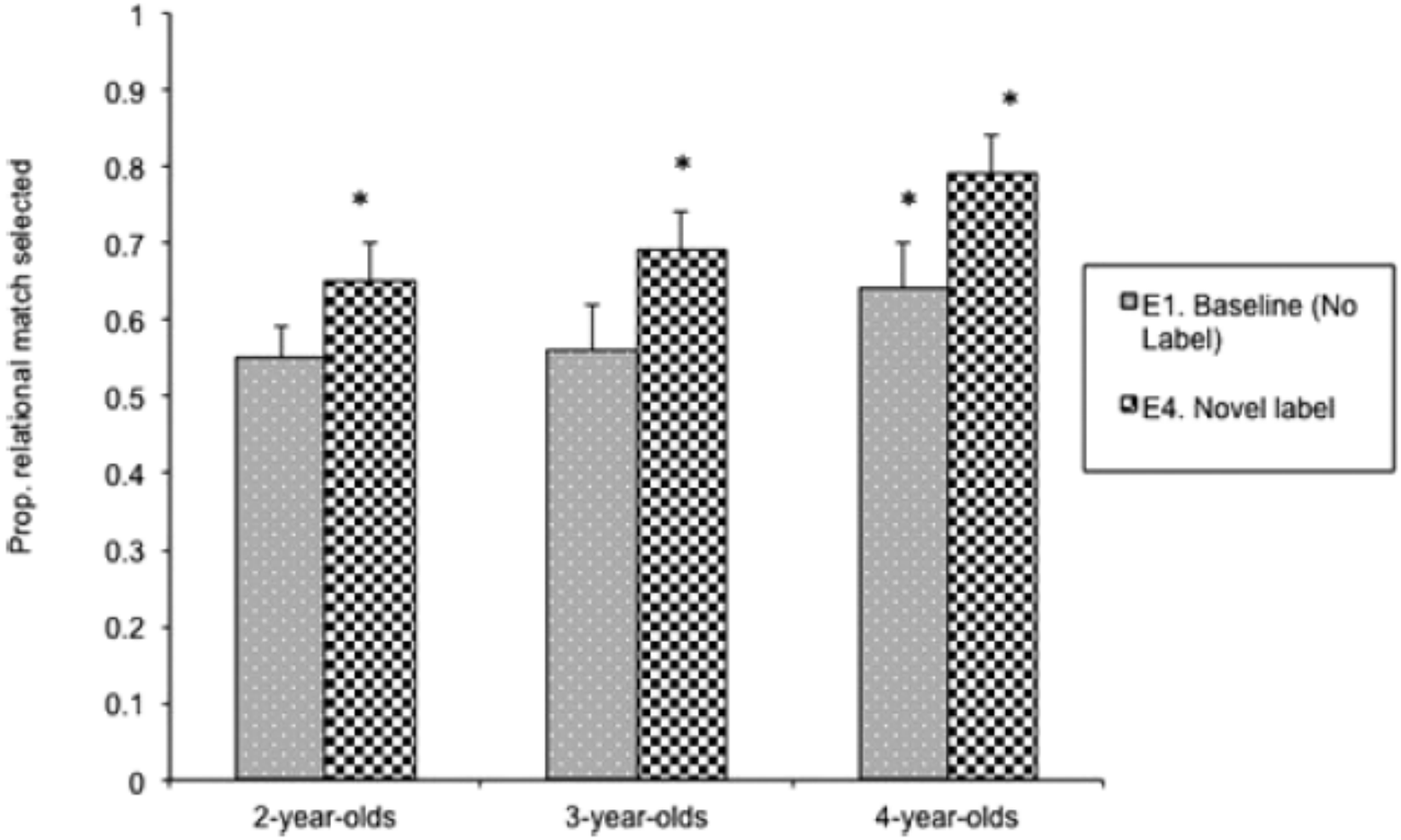


This is a **truffet!** Can you tell me which of these two is the other « Truffet » ?





Christie & Gentner, Cognitive Science, 2013



Christie & Gentner, Cognitive Science, 2013

L’acquisition des mots (langage) aide le raisonnement analogique

Traitement des relations de premier et second ordre chez l’animal ?

Catégorisation (pigeons)

Human

NonHuman

Herrnstein & Loveland, Science, 1964

Objets « naturels »

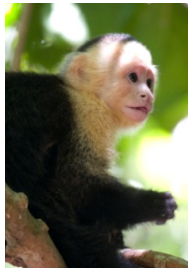
- Homme vs autre, Herrnstein & Loveland, 1964 (pigeon)
- Poisson vs autre, Herrnstein & de Villiers, 1980 (pigeon)
- Feuilles de chêne vs autres feuilles, Cerrella, 1979 (pigeon)
- Paysages avec ou sans arbres, Herrnstein, Loveland & Cabe, 1976 (pigeon)
- Paysages avec ou sans étangs, Herrnstein et al., 1976 (pigeon)

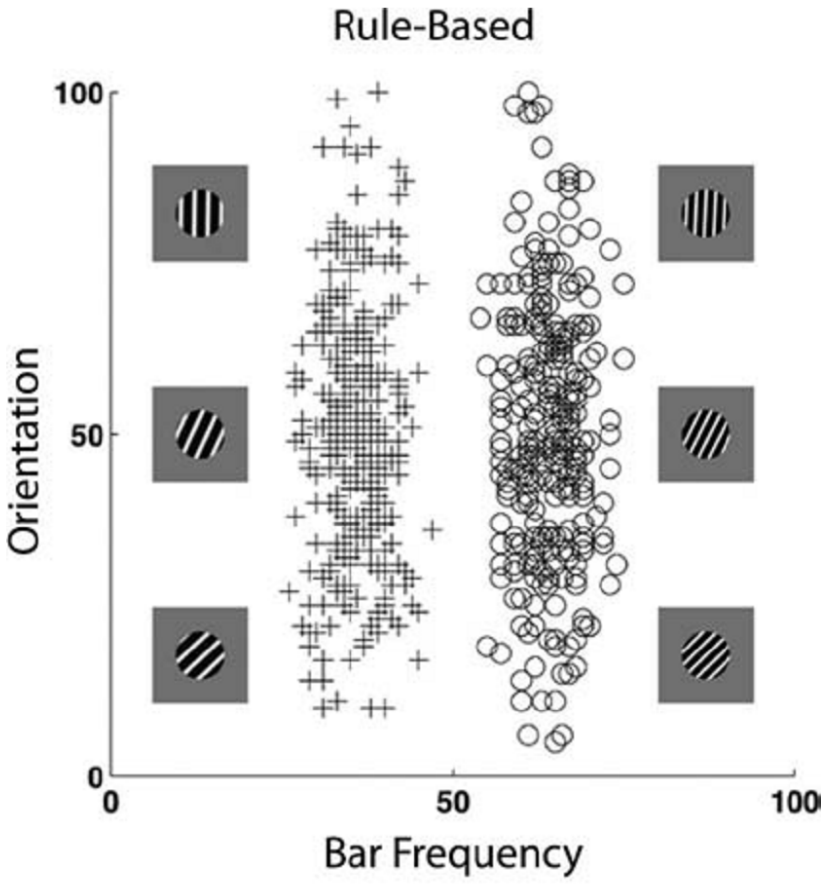
- Homme vs autre, D'Amato & Van Sant (Capucin)
- Homme vs babouin, Martin-Malivel, Fagot & Biederman, 2006 (babouin)
- Aliment vs non-aliment, Bovet & Vauclair, 1998 (babouin)
- Animal vs non-animal, Fabre-Thorpe, Richard & Thorpe, 1998 (macaque)

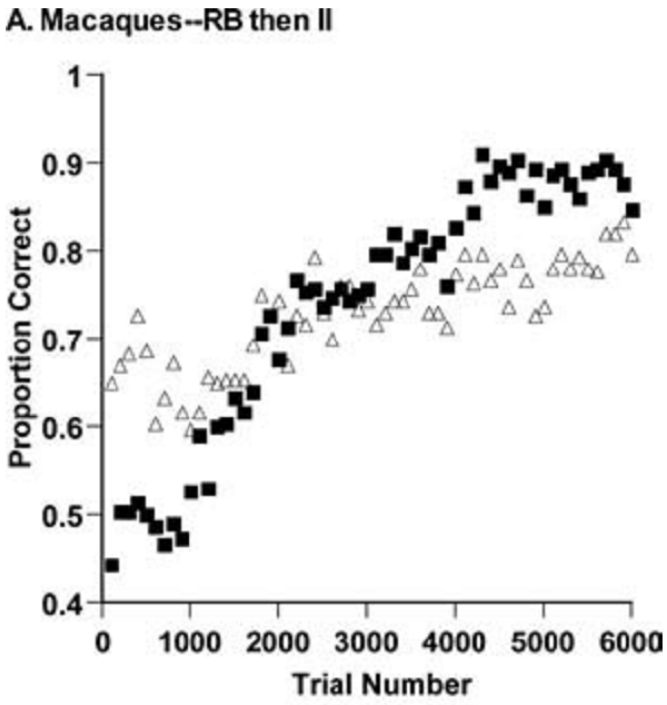
Objets artificiels

- Caractères alphanumériques, Fagot & Vauclair, 1996 (babouin)
- Tableaux de Monet vs Picasso, Watanabe, Sakamoto & Wakita, 1995 (pigeon)
- Photos avec ou sans immeubles, Von Fersen & Lea, 1990 (pigeon)

Catégorisation perceptive

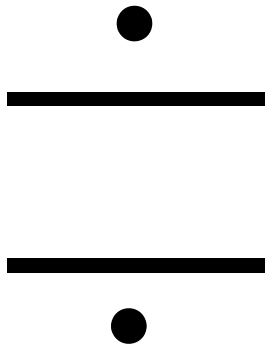






Smith et al., Neurosci Biobehav Rev. 2012

Catégorisation:
Relations spatiales (topologiques)

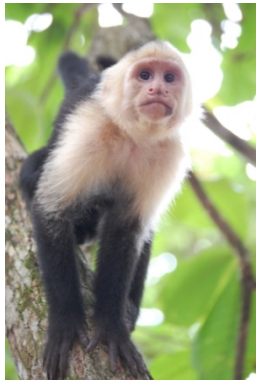


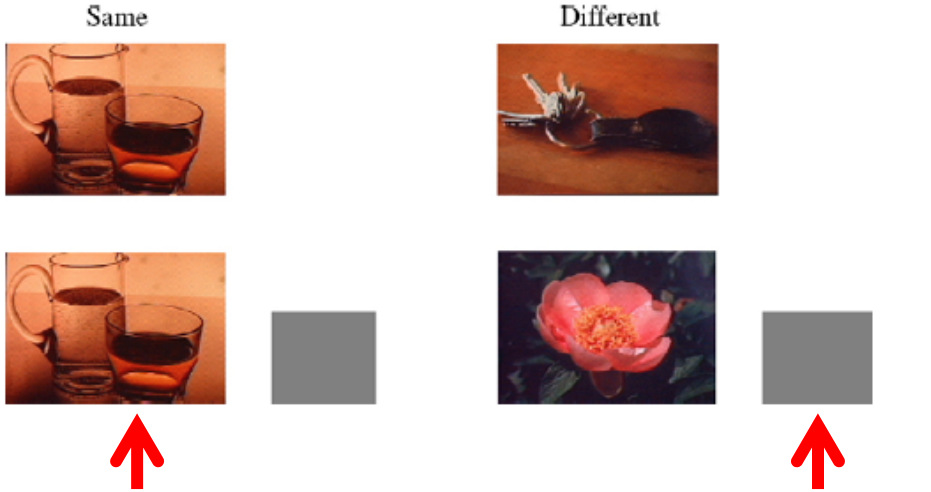
Dessus 3

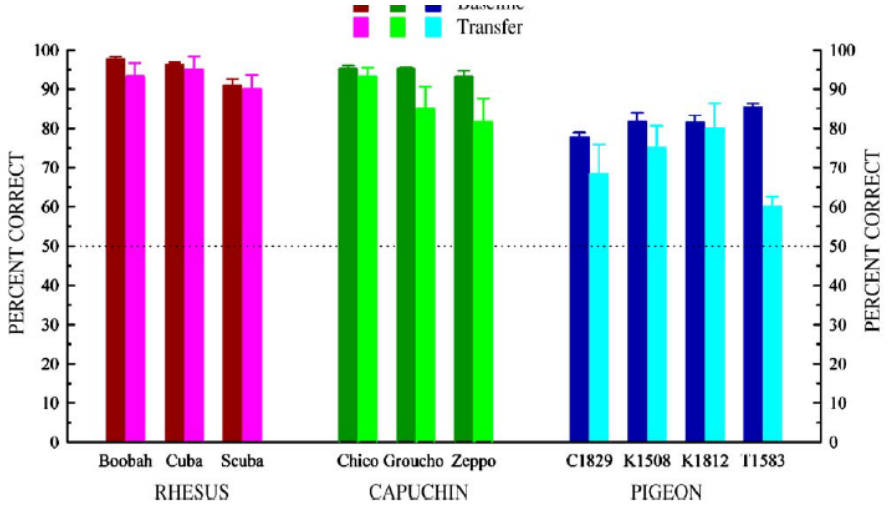
Dessous B

Dépy, Fagot & Vauclair, *Behav. Processing.* 1999

Identité/différence



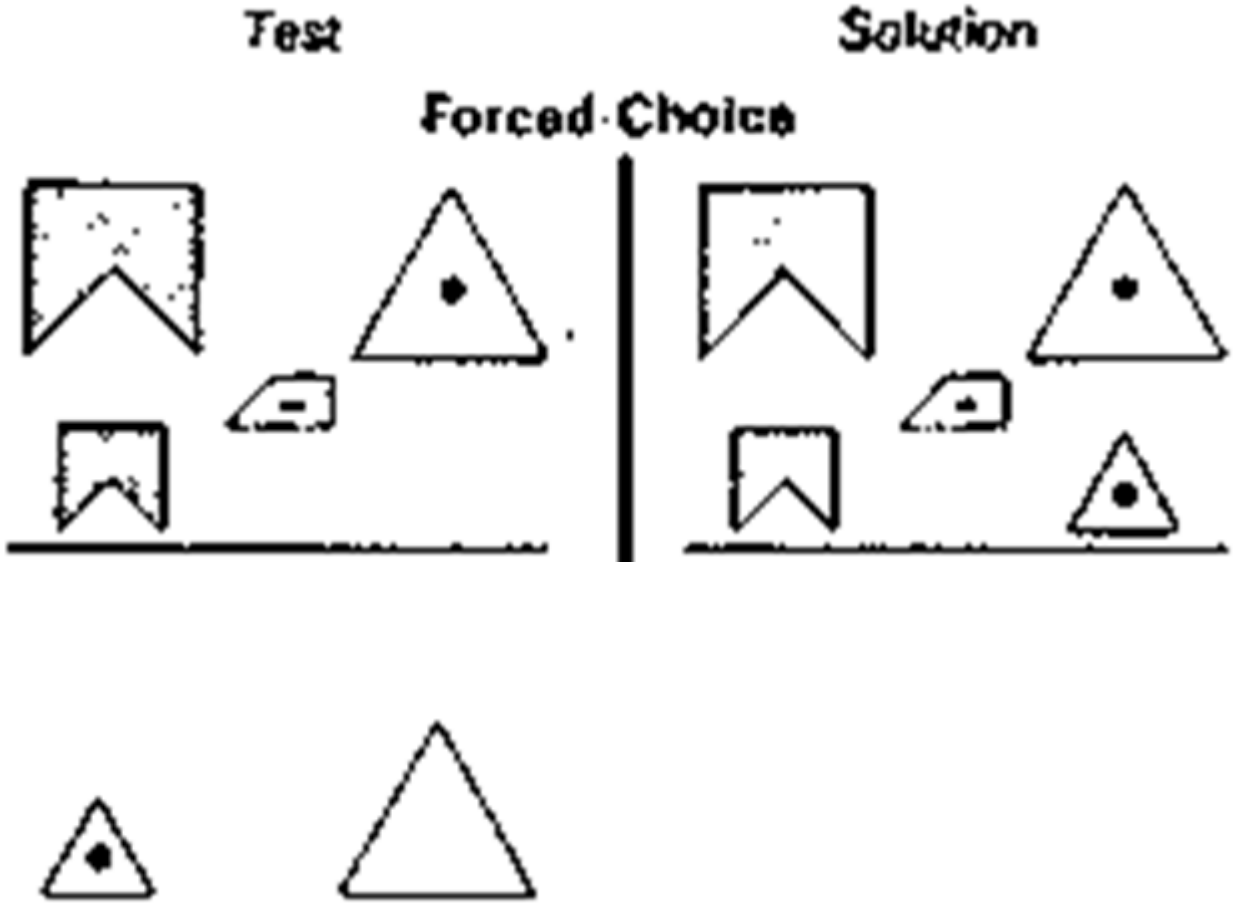


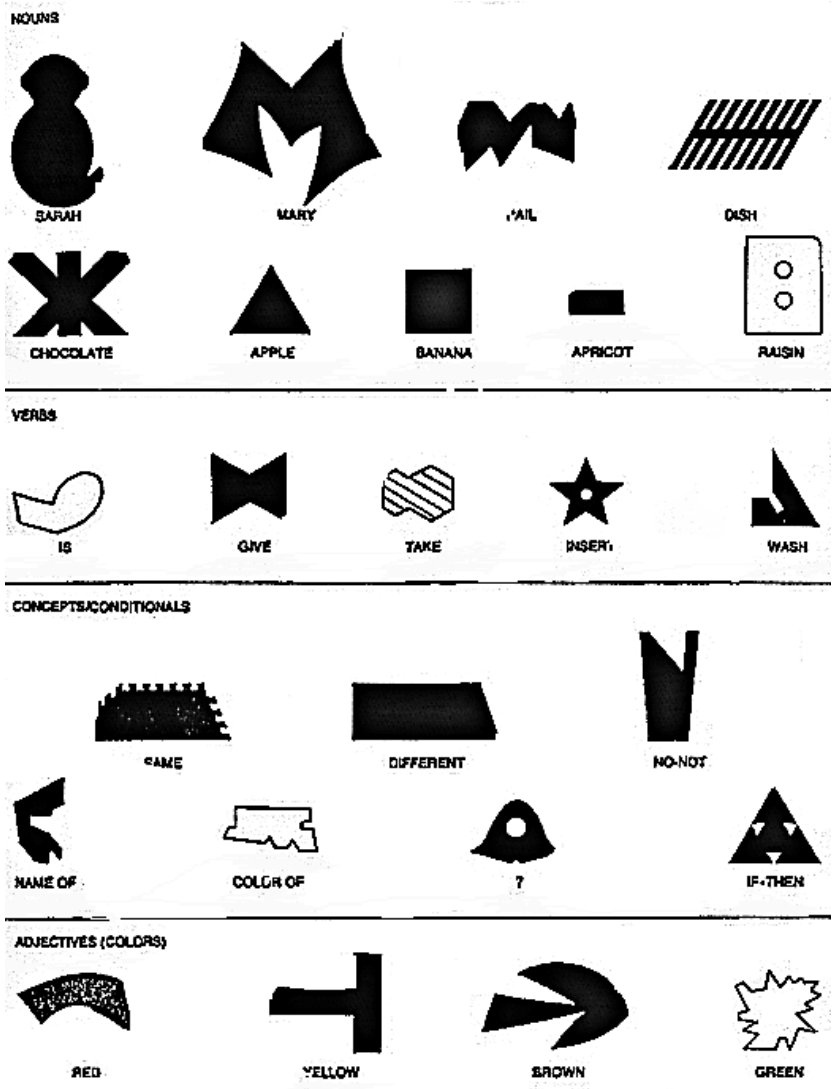


Wright & Katz, Behav. Processing. 2006

Relations entre relations?

Gillan, Premack, and Woodruff (1980). Reasoning in the Chimpanzee: Analogical Reasoning. JEP:ABP





Sarah, le sujet, était un chimpanzé « Language trained»

Premack (1976)

Concepts Conditionals

Same Different

Journal of Experimental Psychology:
Animal Behavior Processes
1997, Vol. 23, No. 1, 31–43

0097-7403/97/$3.00

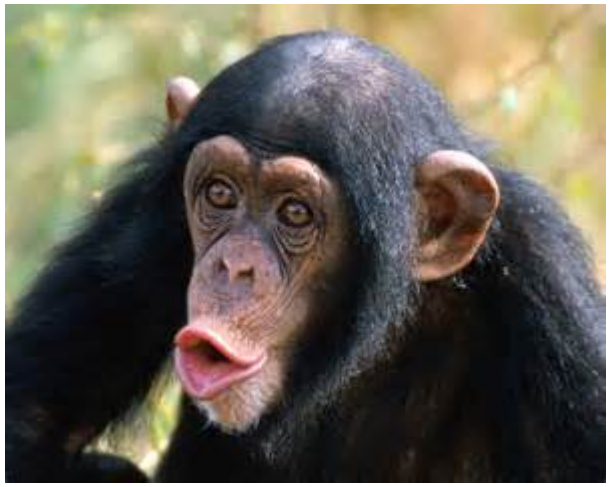
Language-Naive Chimpanzees (*Pan troglodytes*) Judge Relations Between Relations in a Conceptual Matching-to-Sample Task

Roger K. R. Thompson
Franklin and Marshall College

David L. Oden
La Salle University

Sarah T. Boysen
Ohio State University

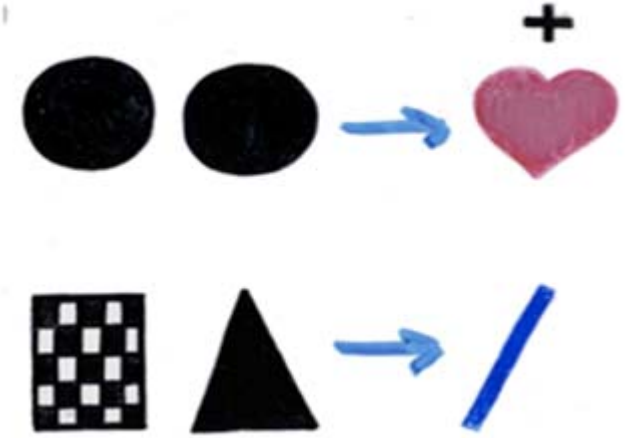
Sarah – « Language trained » (Premack)



Darell

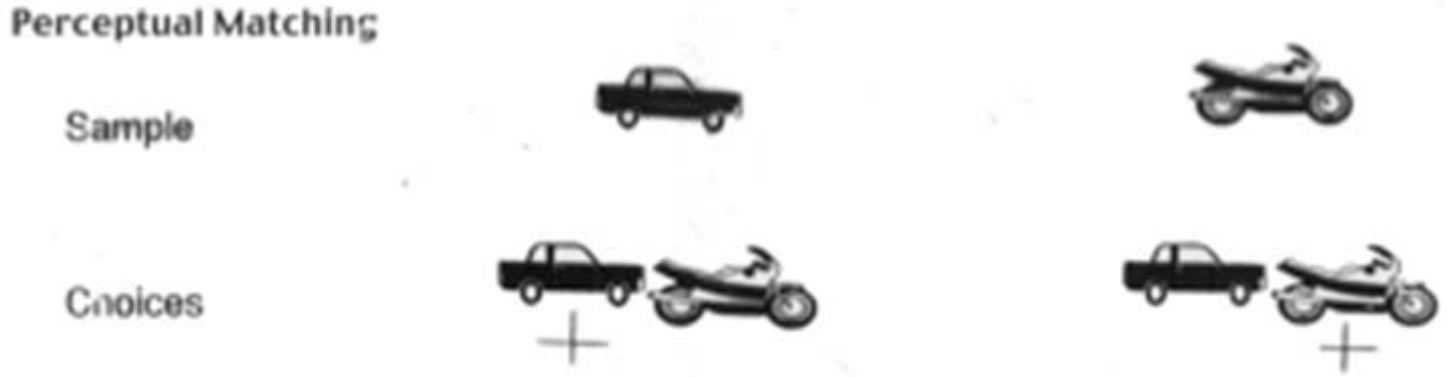
Sheba → « Token trained »

Kermit

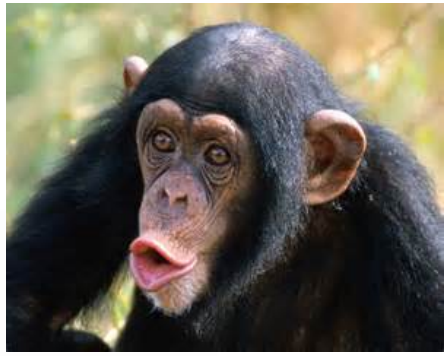


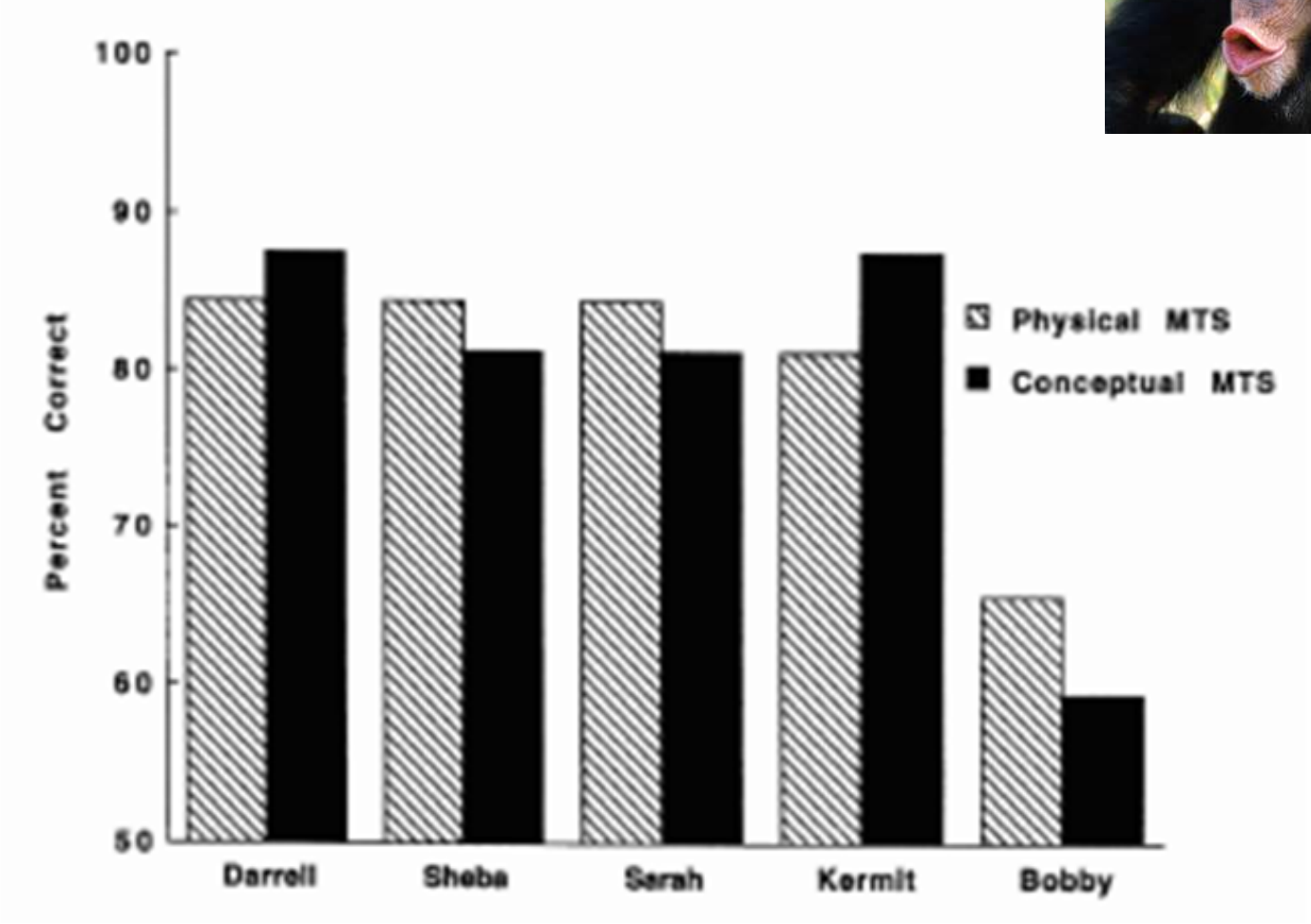
Bobby → Naïf

Thompson, Oden & Boysen, JEP:HPP, 1997

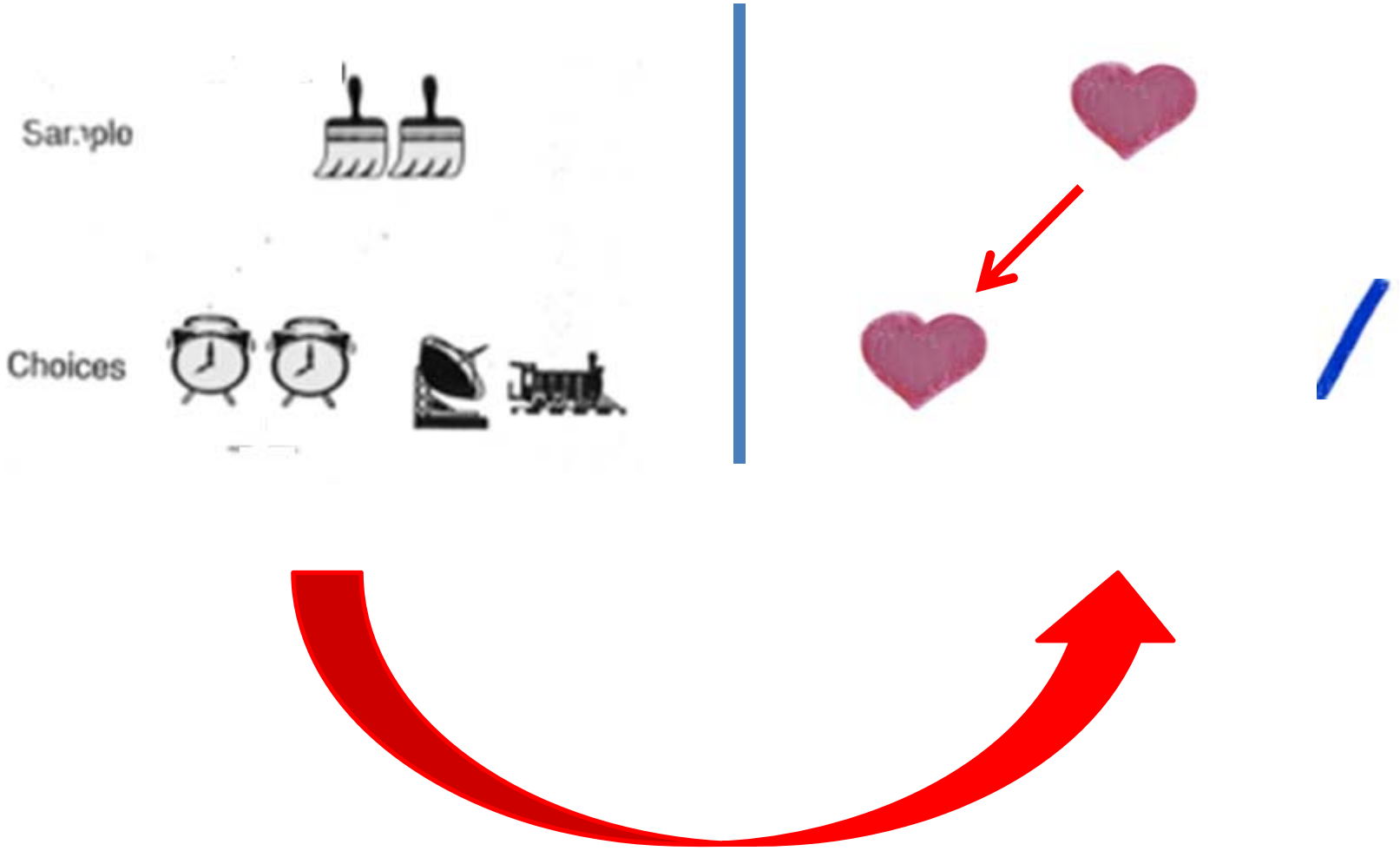


Tâche d'appariement relationnel



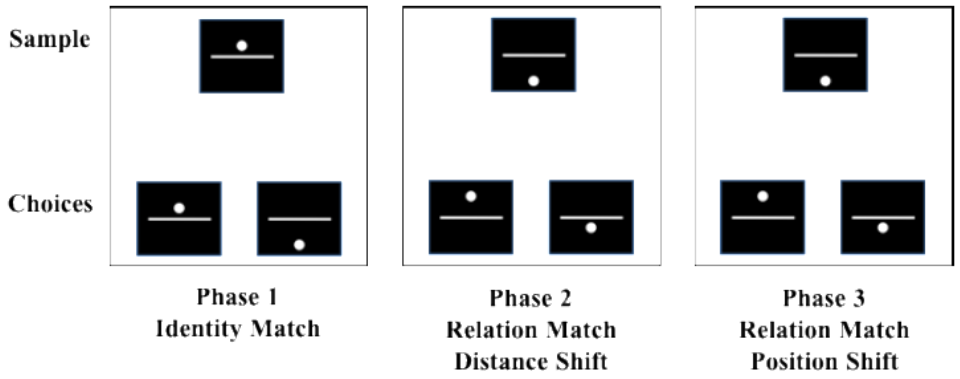


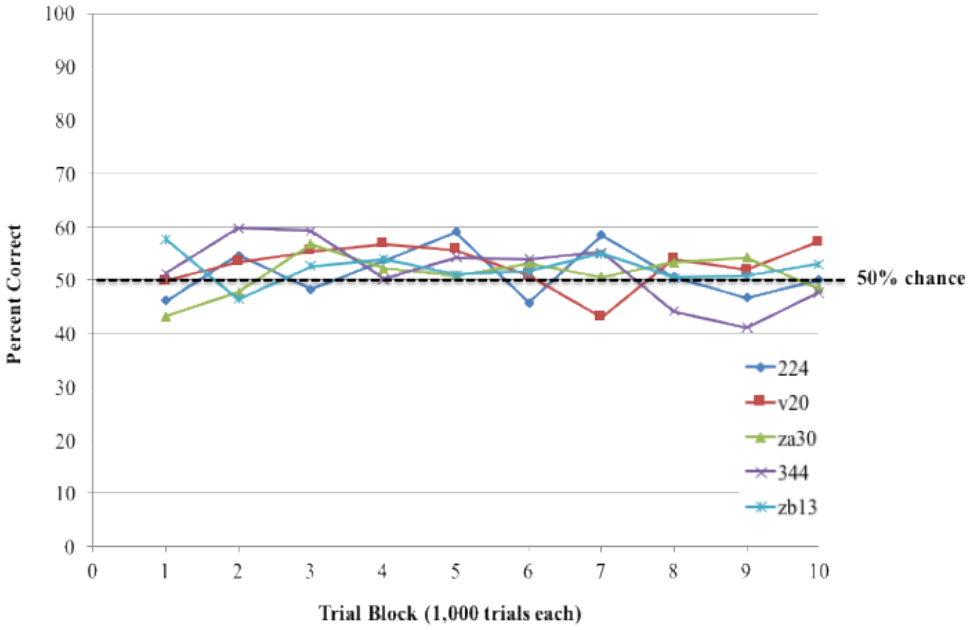
Thompson, Oden & Boysen, JEP:ABP, 1997



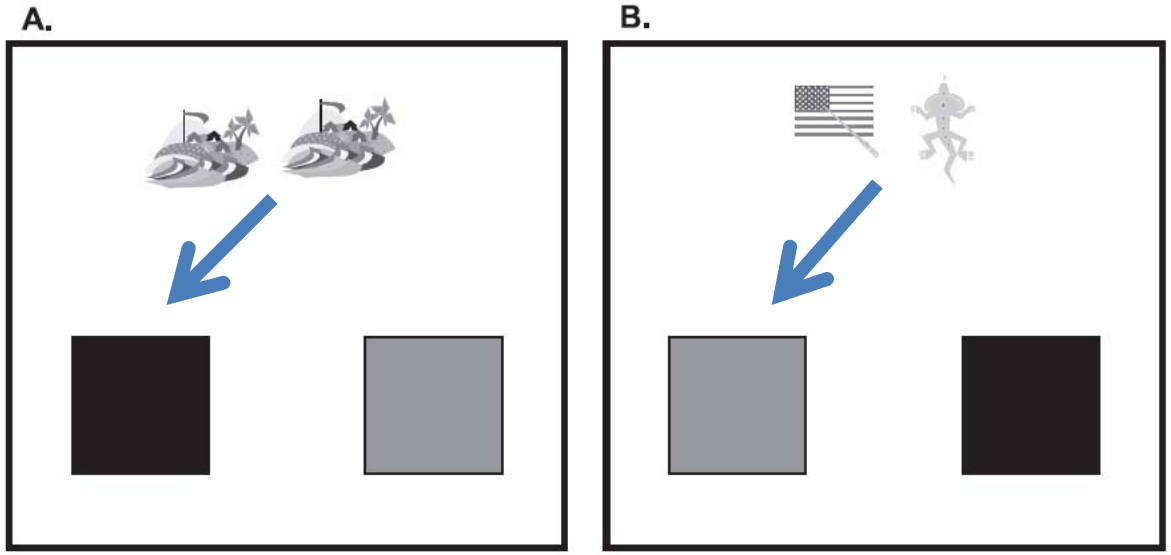
Encodage

Différences phylogénétiques



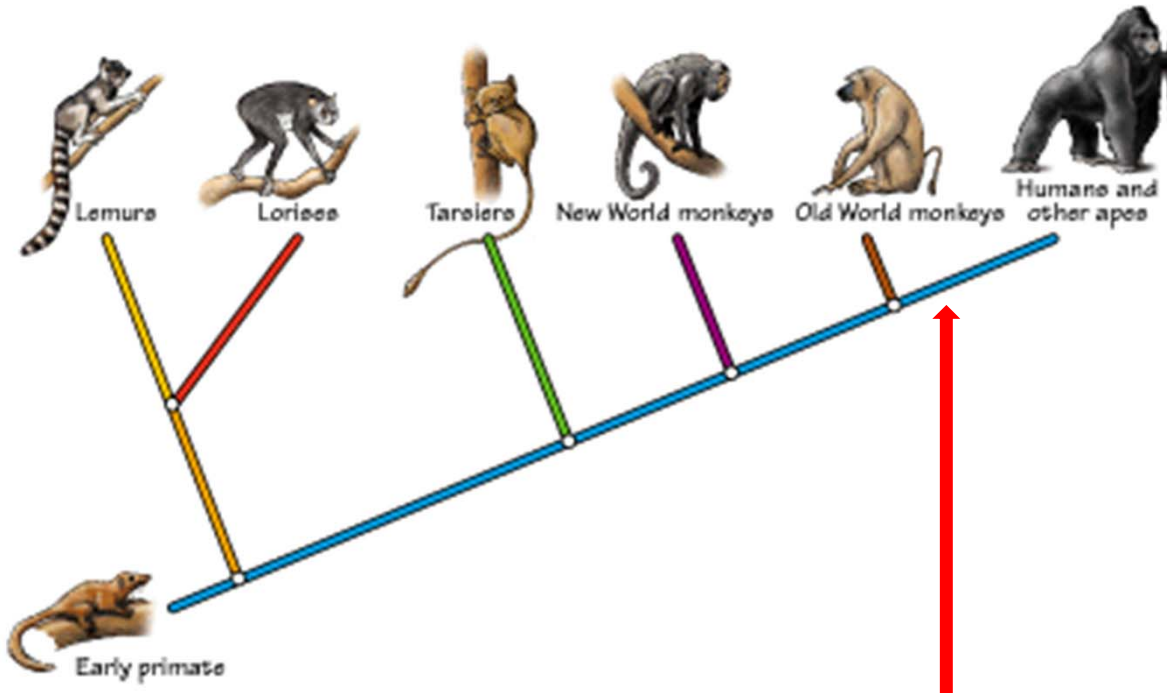


Thompson, Flemming, Hagman, Behavioral Processes, 2015



Appariement relationnel impossible après entraînement à la « labellisation »

Flemming et al., JEP:ABP,2007



« Paleological monkey »

Relations de 1er ordre

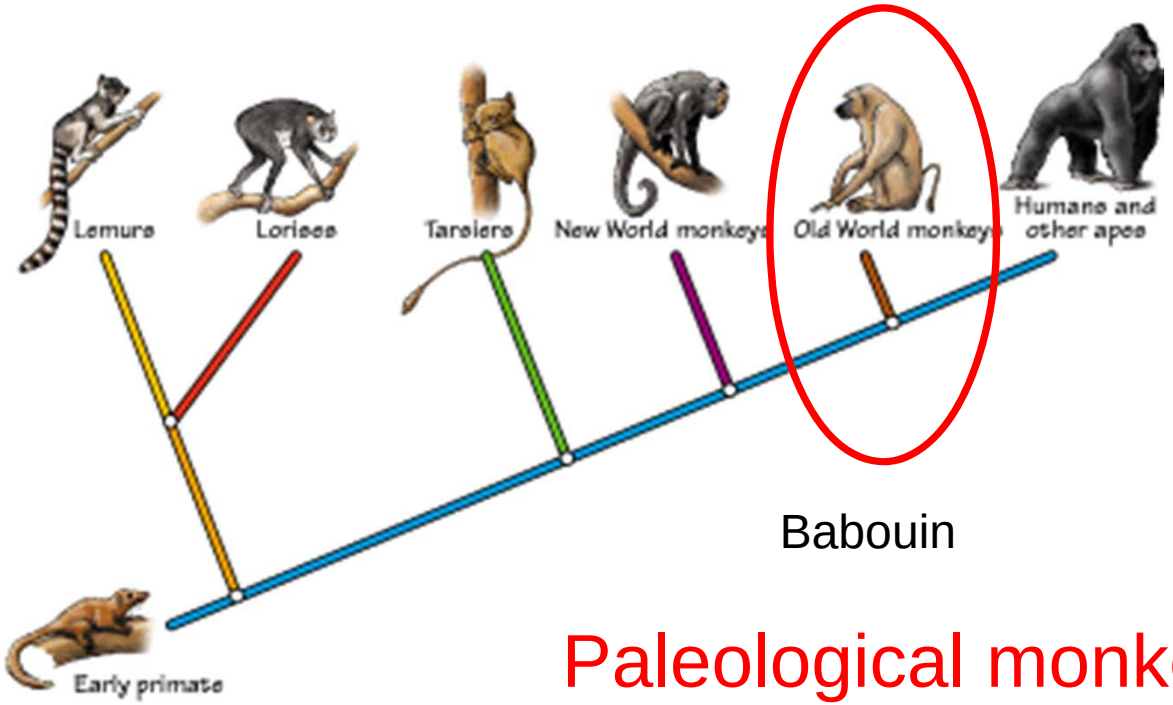
« Analogical ape »

Relations de 2d ordre

Contribution expérimentales

Appariement relationnel chez le babouin non entraîné à la labellisation

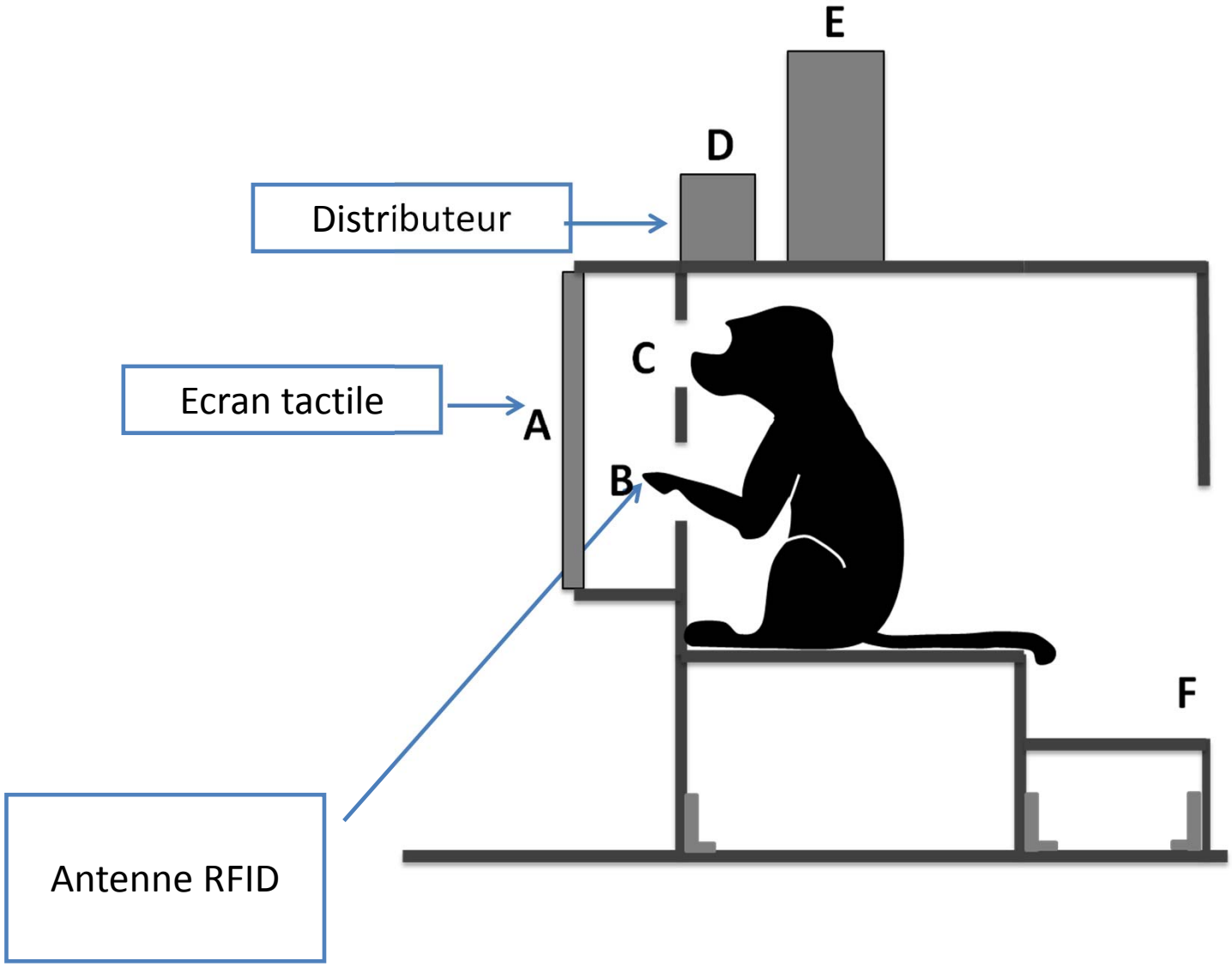
Babouin de Guinée (*Papio papio*)



Babouin

Paleological monkey

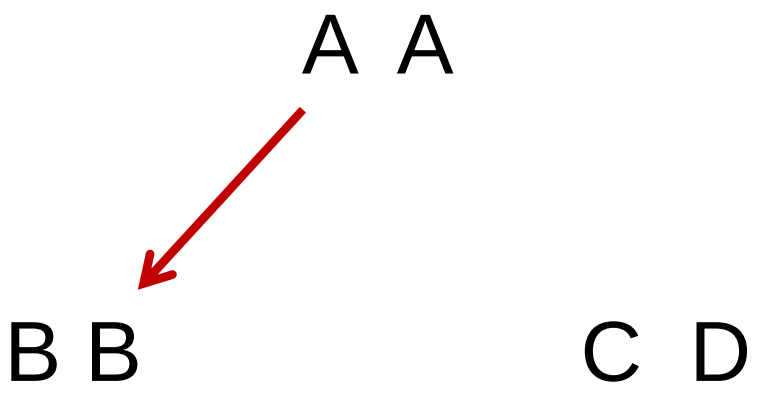
Operant conditioning test systems


E
D
Distributeur
C
Ecran tactile
A
B
F
Antenne RFID

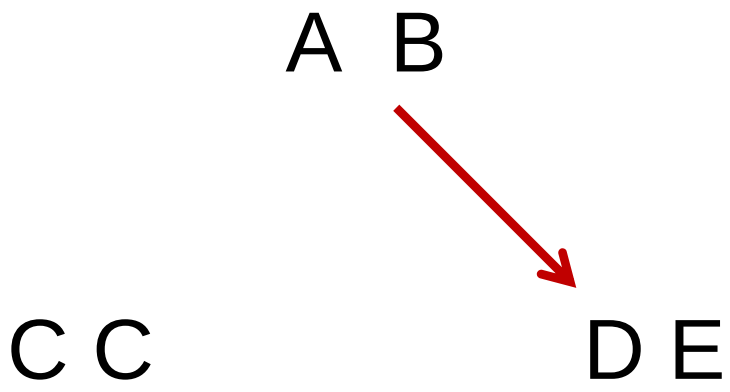
- Motivation élevée
- Amélioration des performances
- Amélioration du bien-être animal

Fagot & Palleresompoule, Behavioural Research Methods, 2009;
Fagot & Bonté, Behavioural Research Methods, 2010,
Fagot et al. Am. Journal of Primatology (2014)

Appariement relationnel

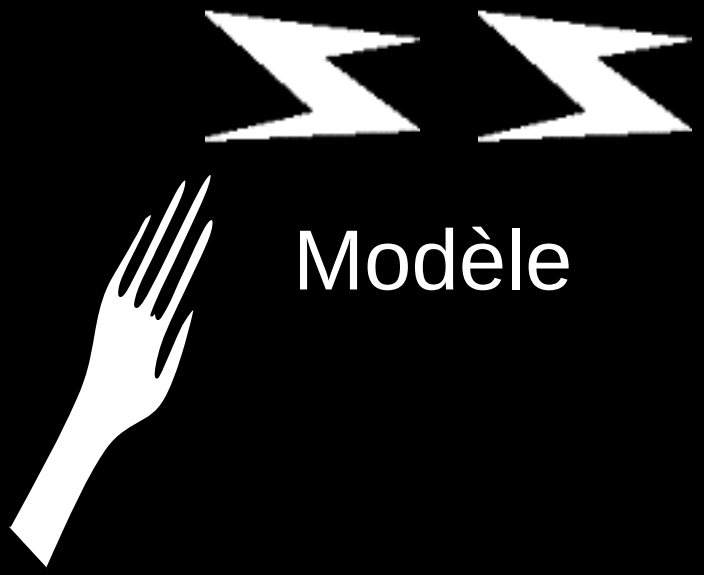


« Identique »



« Différent »

« Identique »



Modèle

blé

S+

S-

Apparie identique avec identique

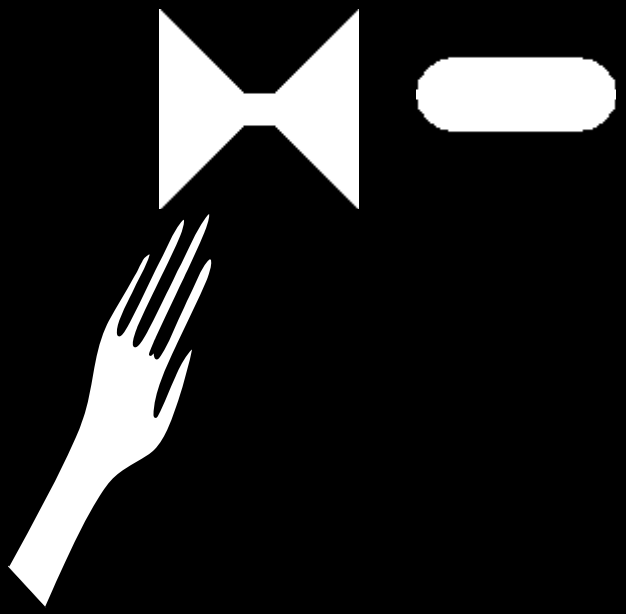
Erreur

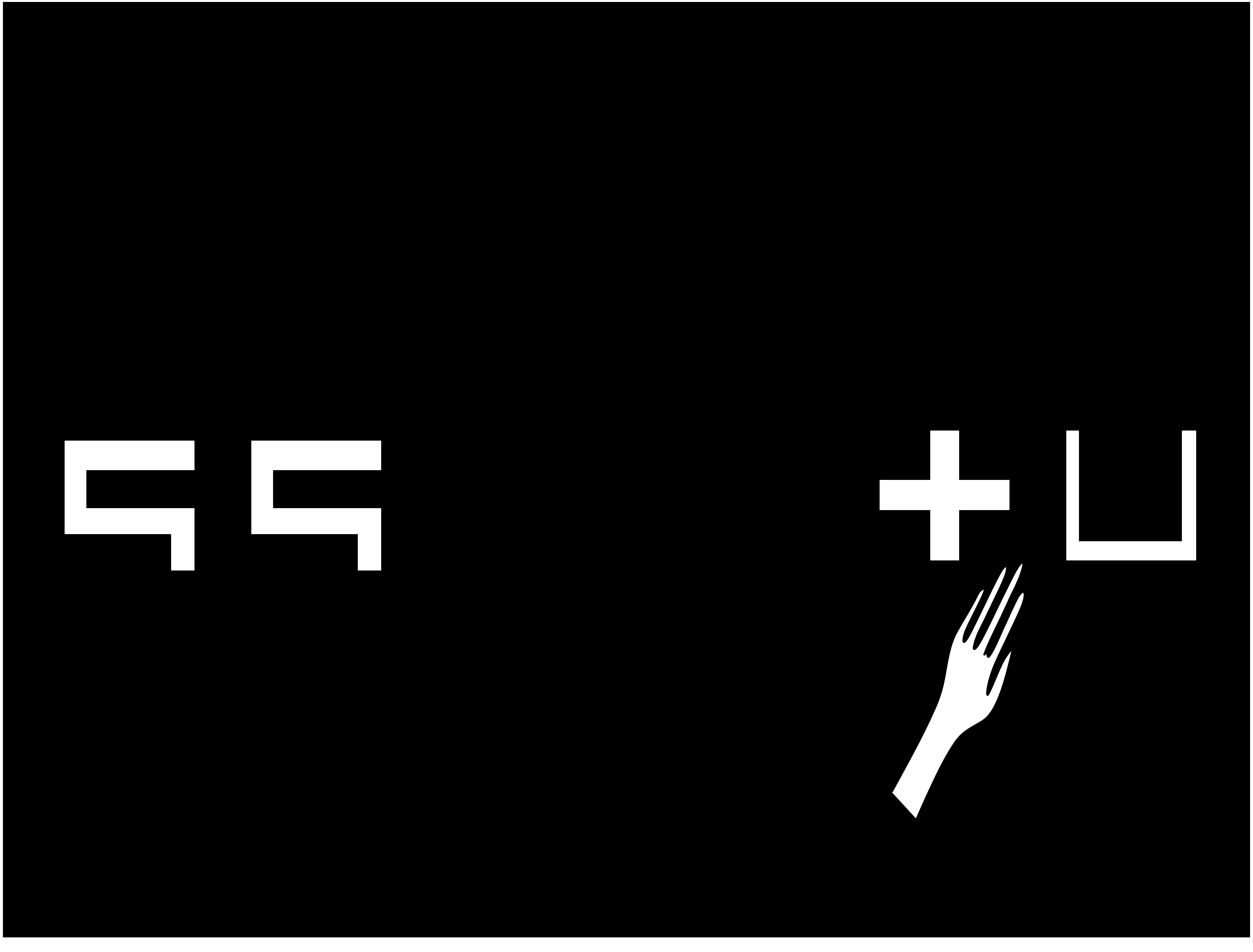
Délai

S+

S-

« Différent »





Procédure

- Sessions (50% « identiques» / 50% « différents »)
- Renforcement différentiel

  Réponse correcte -> Récompense

  Réponse incorrecte -> Délai

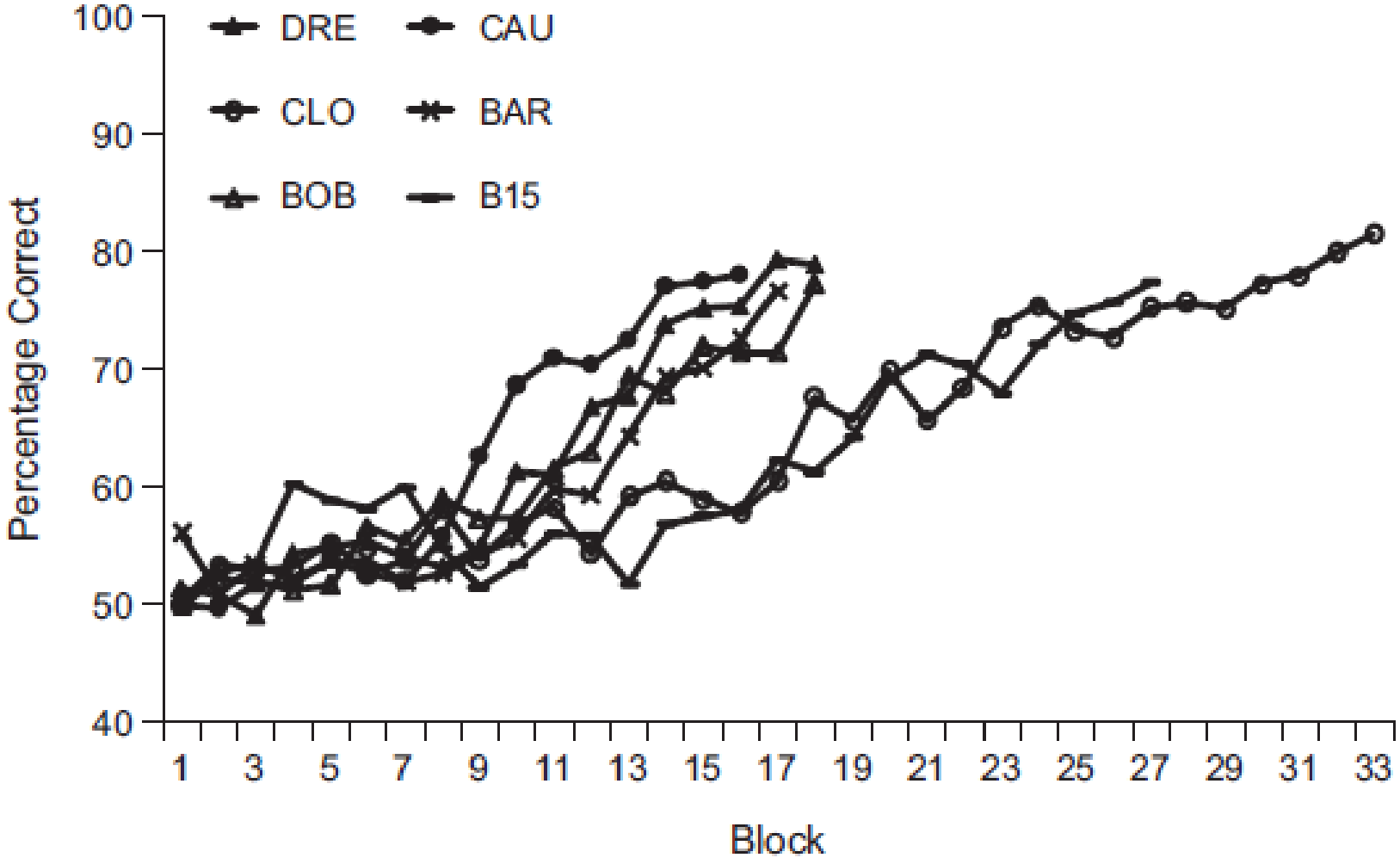
- 4 semaines d'entraînement
- 29 babouins
- 647 000 essais d'entraînement

Table 1. Demographic Information and Experimental Data for the Subjects in Experiment 1

Baboon	Test location	Gender	Age (years)	Number of training sessions	Mean percentage of correct responses
DRE	Rousset	Female	1.6	179	81.3*
CAU	Rousset	Male	1.9	154	81.7*
CLO	Rousset	Male	2.1	321	81.0*
BAR	Rousset	Male	2.7	169	80.0*
ARI	Rousset	Female	3.4	406	65.6
ART	Rousset	Male	3.4	222	76.6
BOB	Rousset	Male	3.4	179	84.7*
ANG	Rousset	Female	3.8	302	61.7
VIO	Rousset	Female	4.2	376	61.7
VIV	Rousset	Male	4.4	241	72.0
VAN	Rousset	Female	4.7	239	53.3
URA	Rousset	Female	5.2	181	51.0
TAR	Rousset	Female	6.7	337	49.3
ROM	Rousset	Female	8.9	93	49.7
PIP	Rousset	Male	10.4	32	49.7
ATM	Rousset	Female	11	165	49.3
MON	Rousset	Female	12	55	51.3
LEA	Rousset	Female	13.1	75	50.0
MIC	Rousset	Female	13.1	105	51.0
KAL	Rousset	Female	13.5	48	50.3
BRI	Rousset	Female	23.8	130	49.7
B03	Marseille	Male	24	150	52.7
B05	Marseille	Male	24	203	56.0
B06	Marseille	Female	24	129	57.7
B07	Marseille	Male	24	157	69.3
B08	Marseille	Female	24	209	51.7
B11	Marseille	Male	24	198	60.3
B15	Marseille	Male	24	270	81.3*
MIL	Rousset	Male	32.2	126	50.0

Fagot & Thompson, Psychological Science, 2011

Courbes d'apprentissage



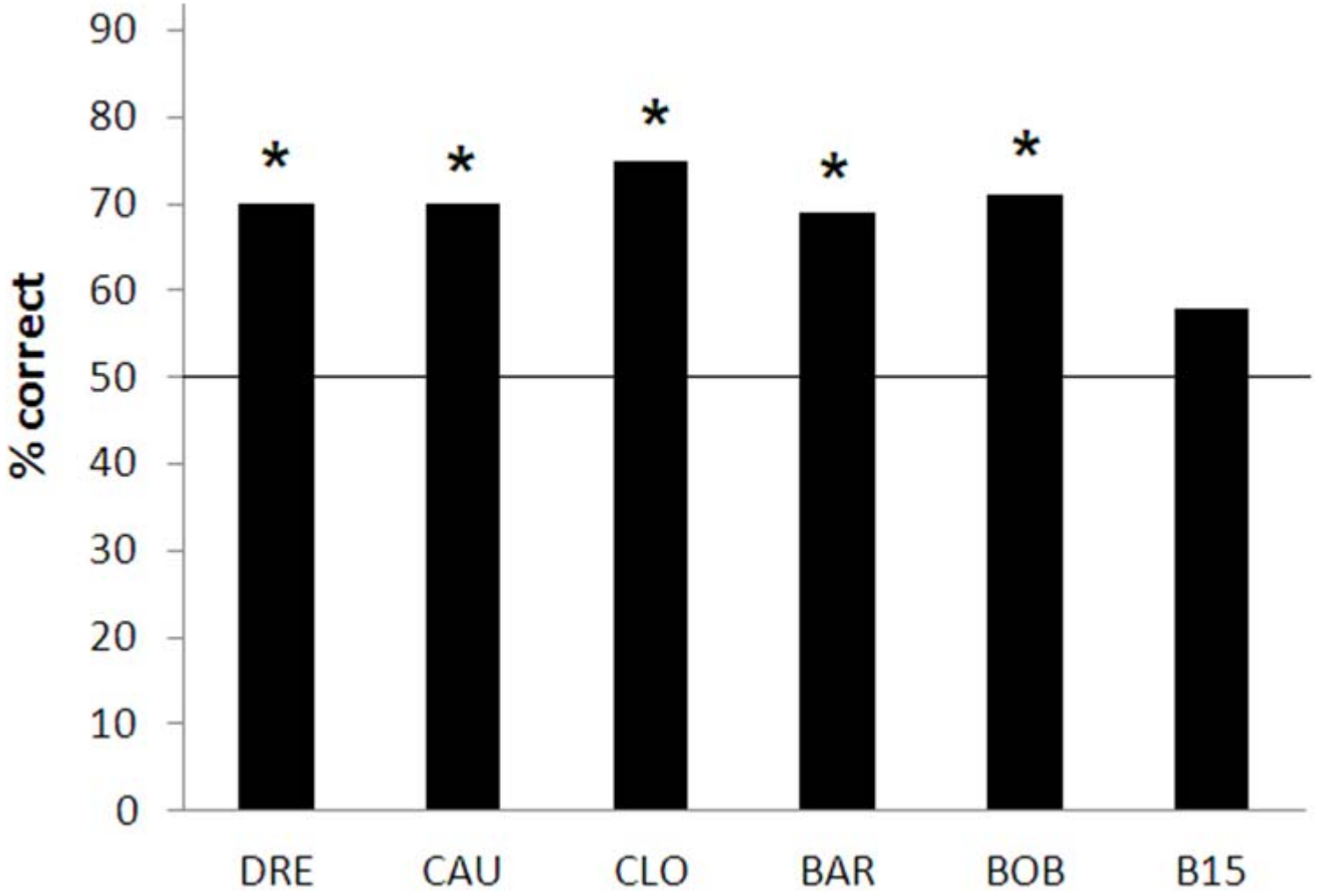
Fagot & Thompson, Psychological Science, 2011

Quelle est leur stratégie ?

Quel type d’information est utilisé ?

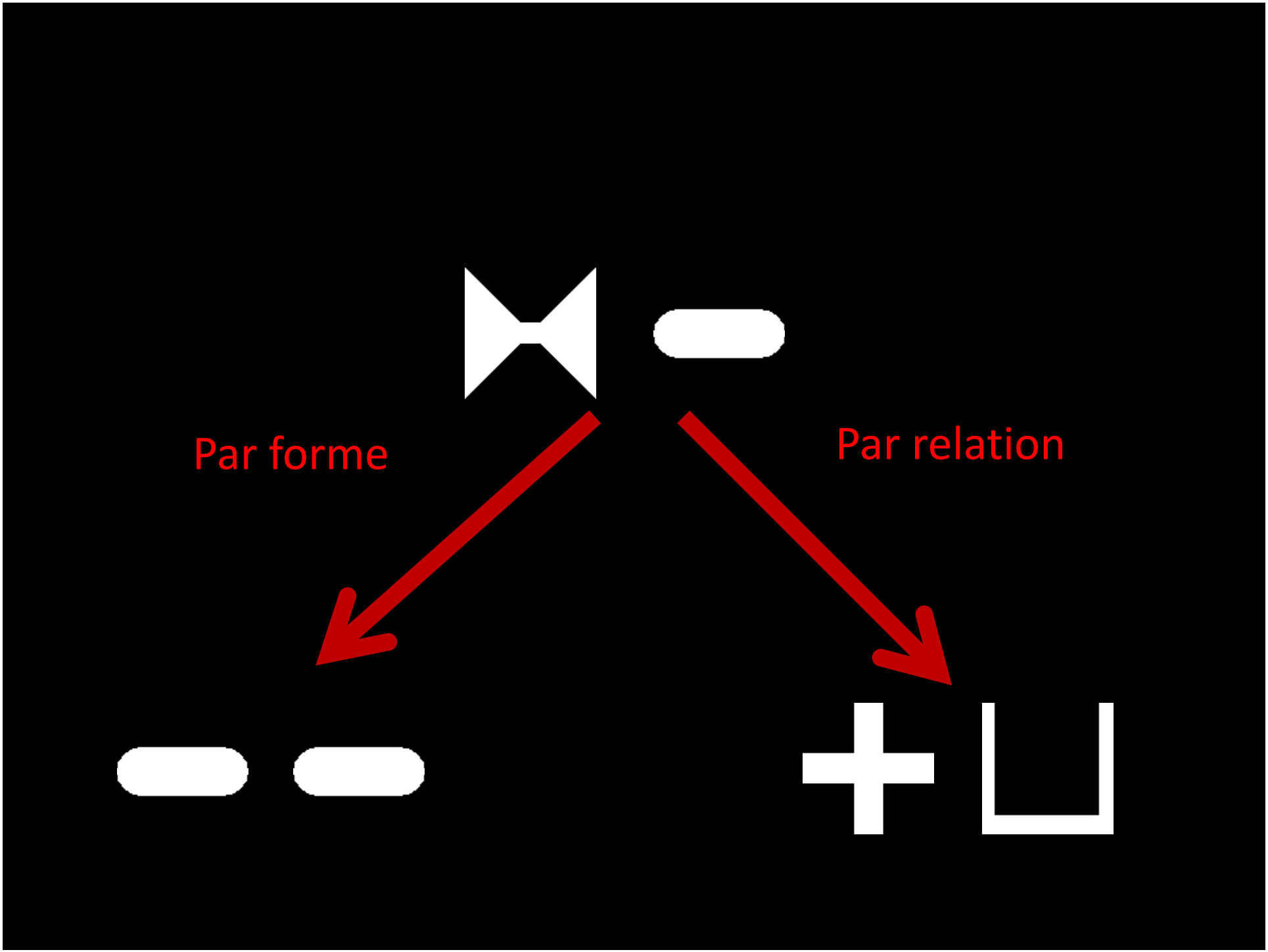
Test de généralisation à de nouveaux stimuli

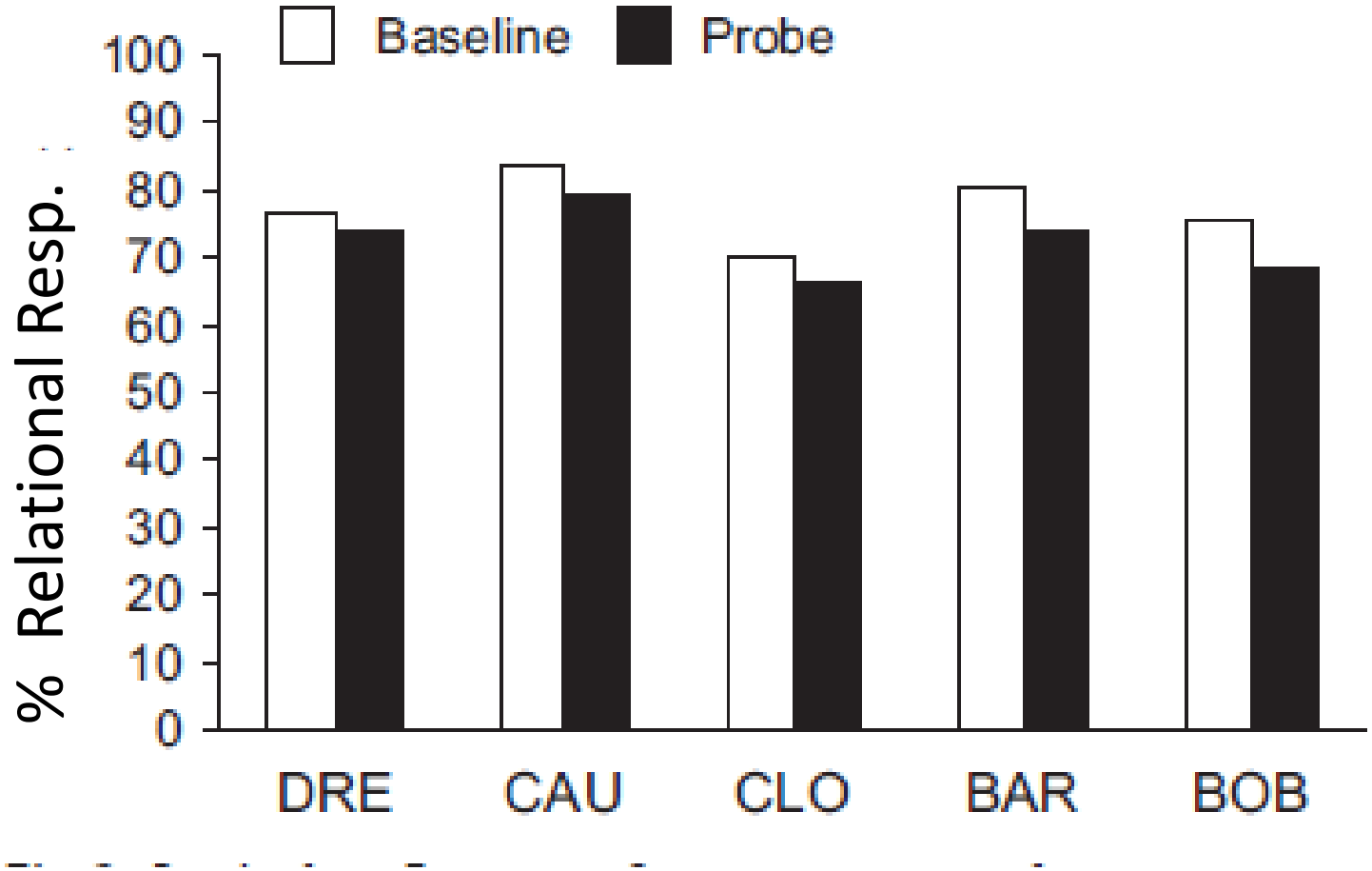
Généralisation (90 nouveaux stimuli)



Fagot & Thompson, Psychological Science, 2011

Essais « Cross-mapped »


Par forme
Par relation



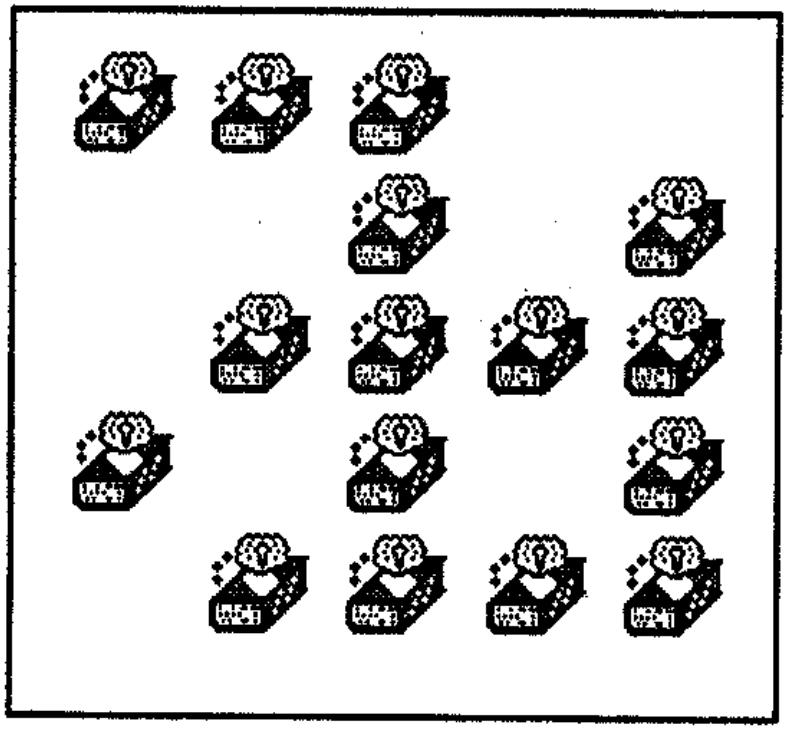
All ps < .05
Baseline (77.5%) > cross-mapped (72.1%), p<.05

Fagot & Thompson, Psychological Science, 2011

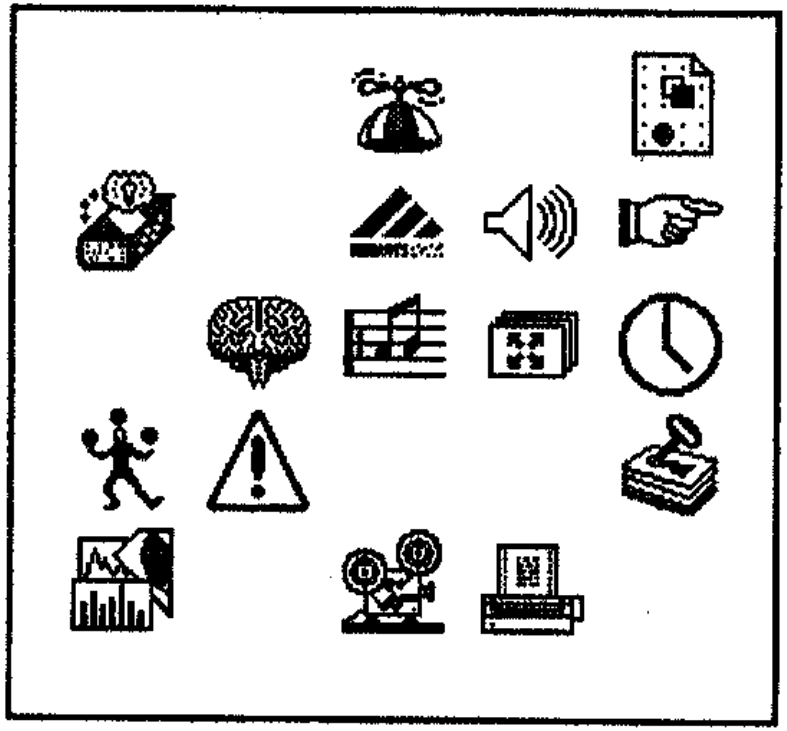
Contribution des indices perceptifs

Appariement par entropie ?

Edward Wasserman

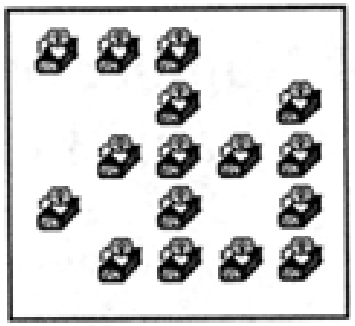


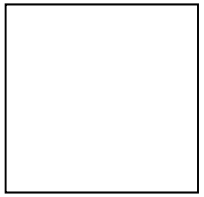
Identique



Différent

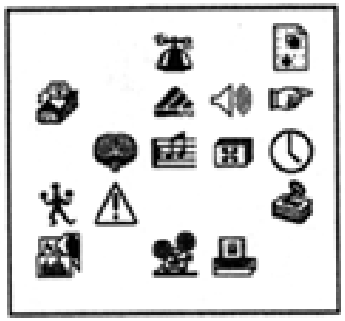
16 icons



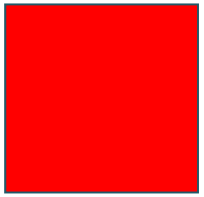


Identique

Identique



Différent

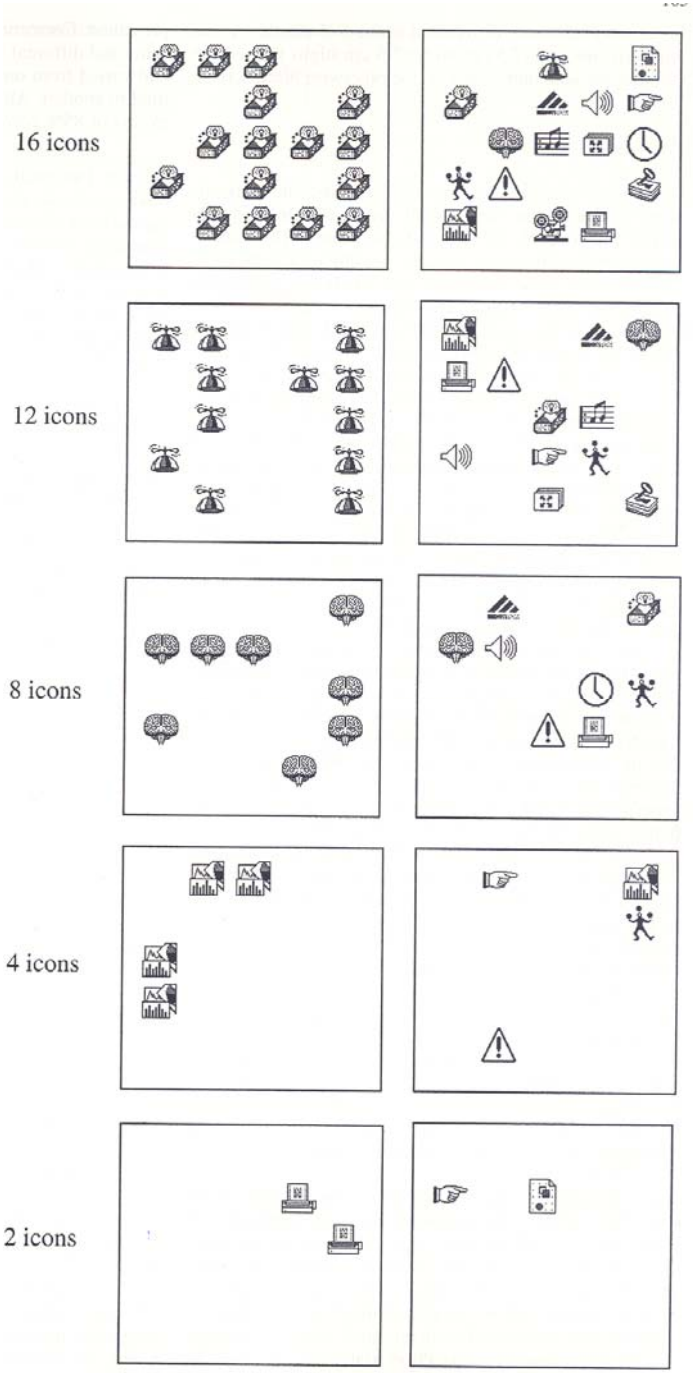


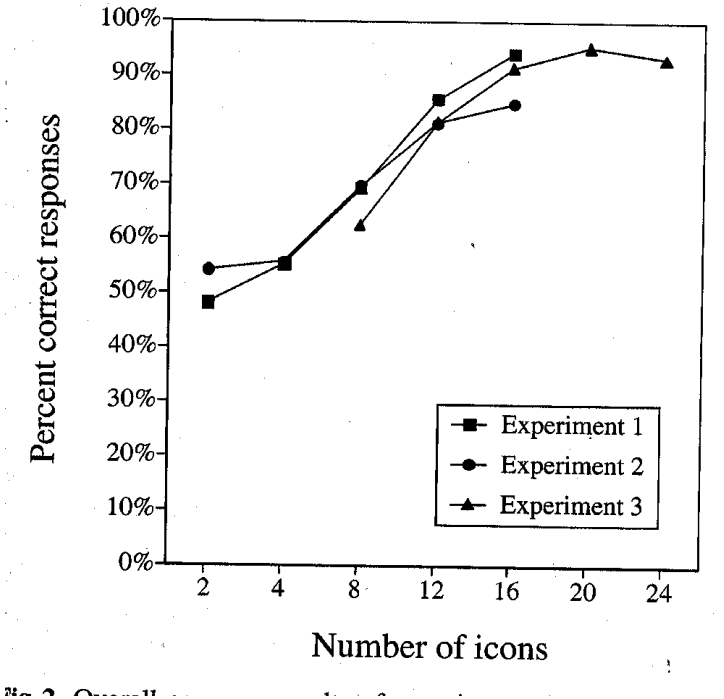
Différent

Wasserman, Fagot & Young, Journal of Comparative Psychology, 2001

Wasserman, Young & Fagot (2001), JCP

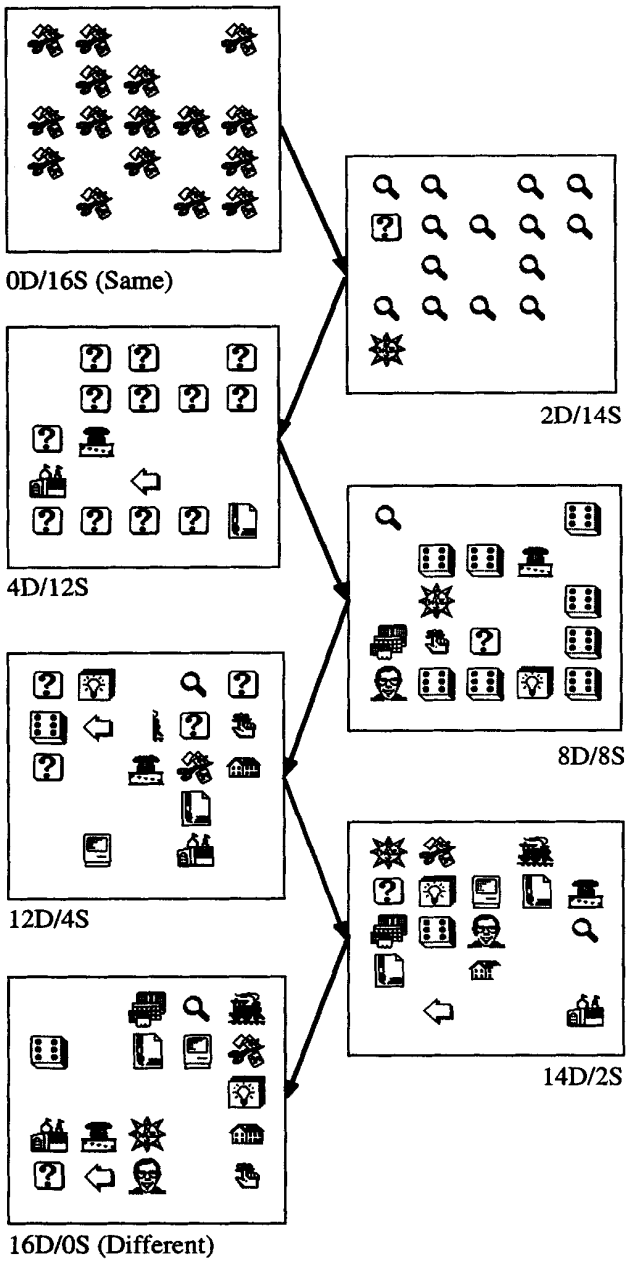
Effet du nombre d'icones

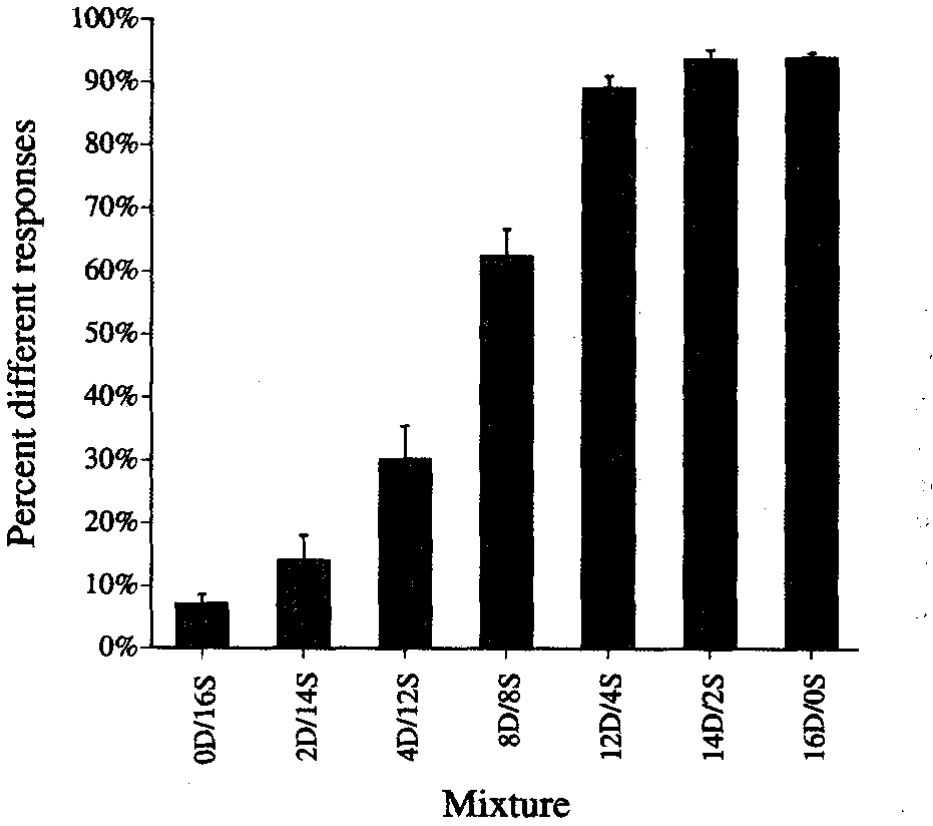




Wasserman, Young & Fagot, Animal Cognition, 2001

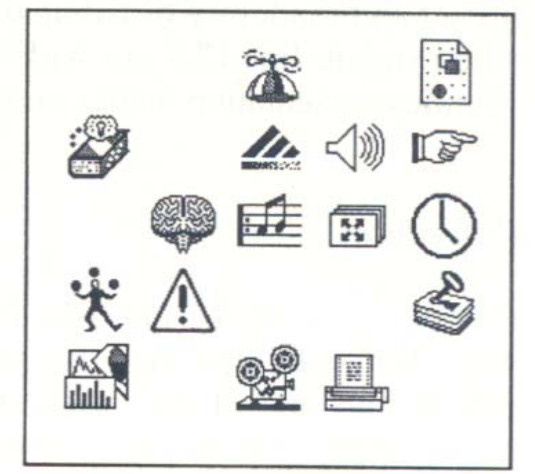
Effet de la distribution des icones





Wasserman, Fagot & Young, Journal of Comparative Psychology, 2001

Entropie de Shannon



$$H(A) = -\sum_{a \in A} p_a \log_2 p_a$$

Nombre d'icones

Proportion de chaque icone

Pauvre en information

Riche en information

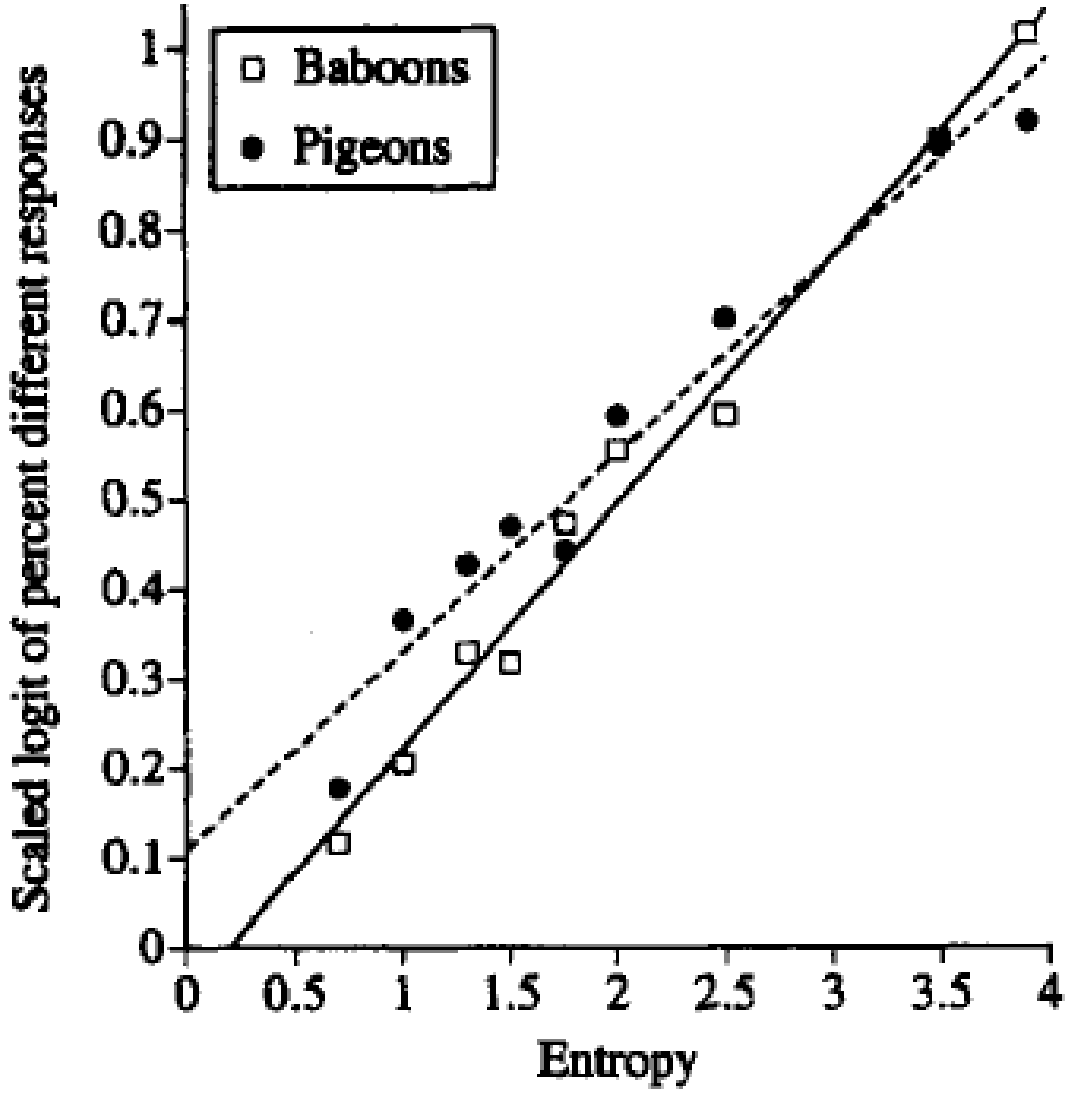
0

4

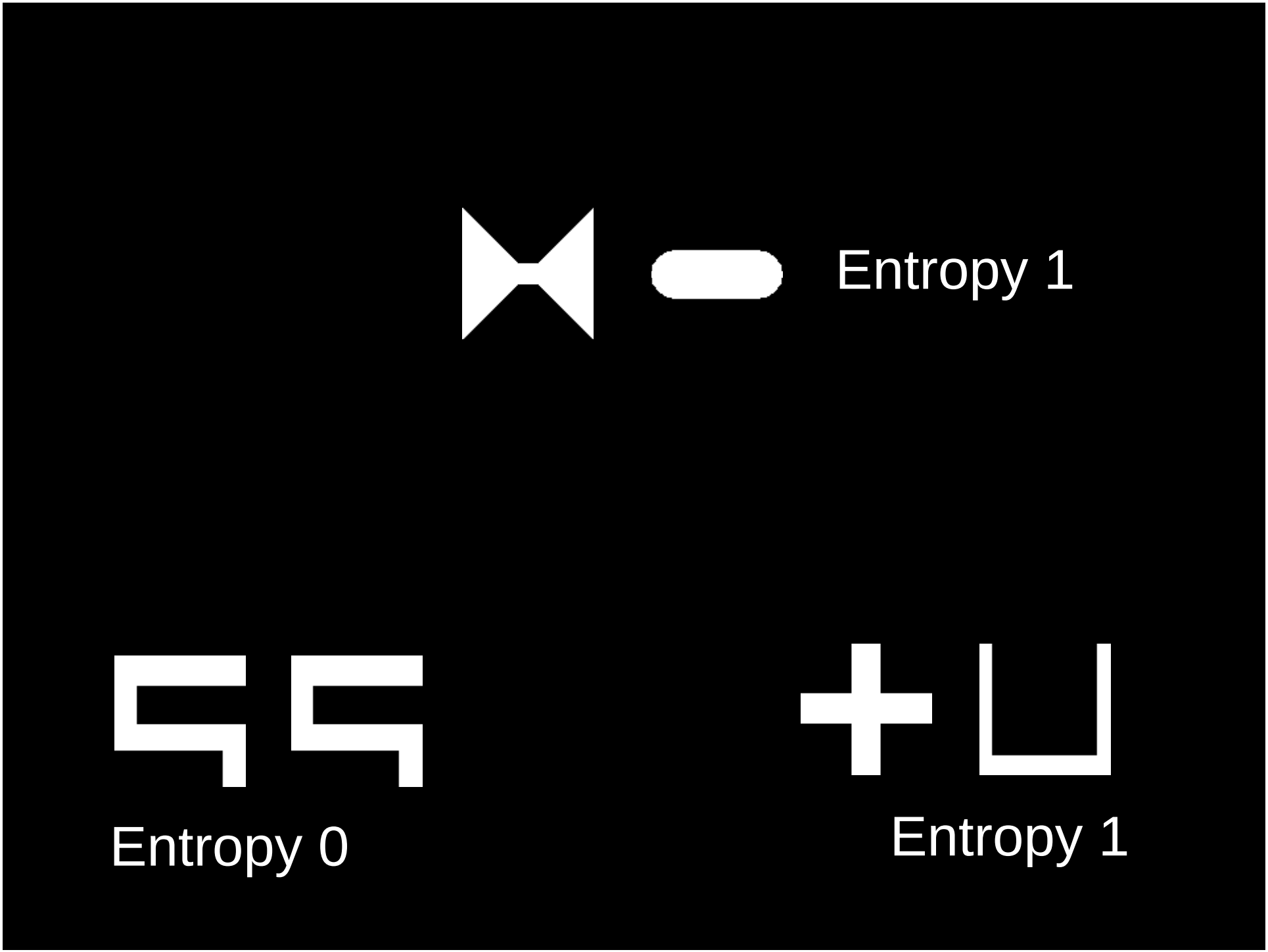
Entropie

Tous identiques

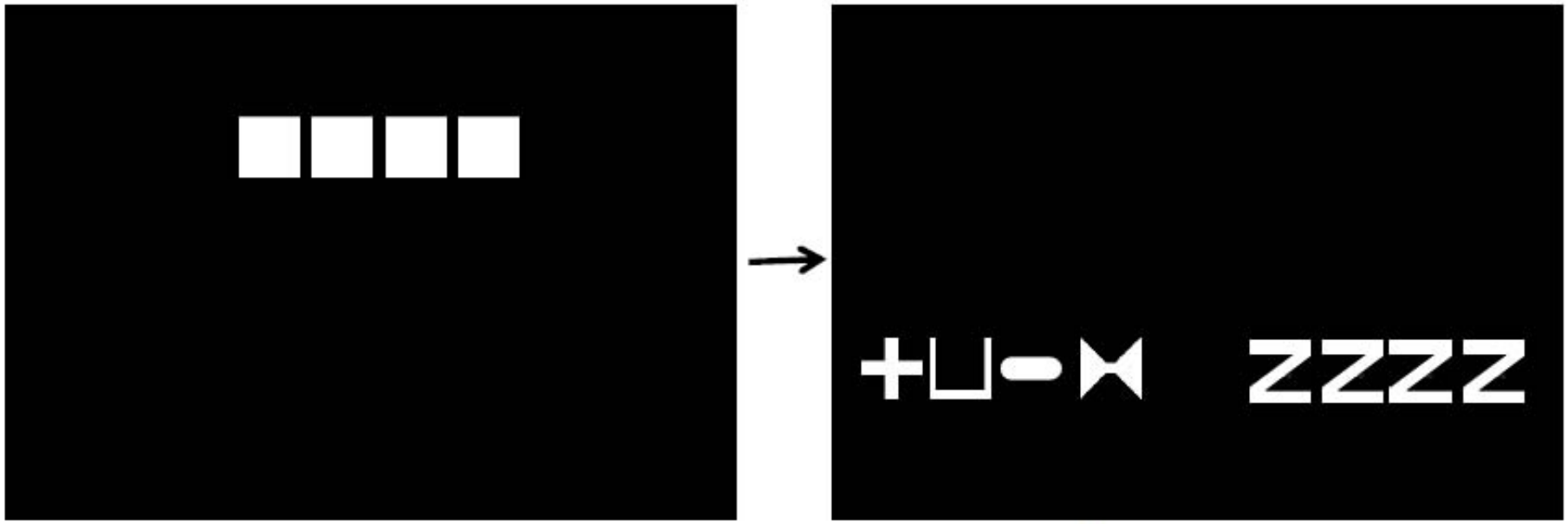
Tous différents



Wasserman, Fagot & Young, Journal of Comparative Psychology, 2001

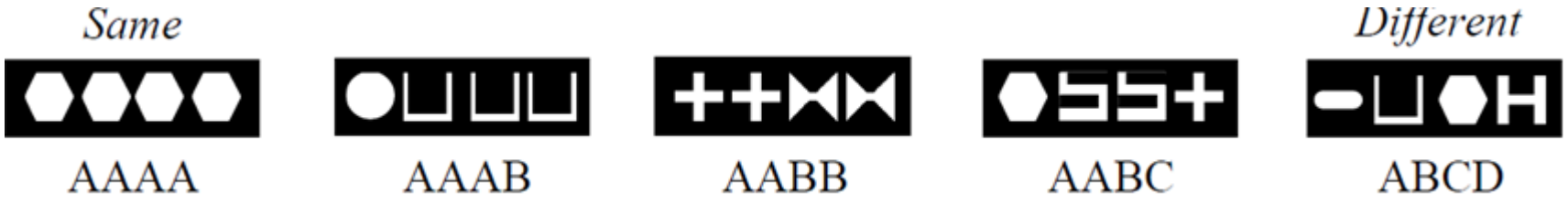

Entropy 1
Entropy 0
Entropy 1

Example trial (baseline sample)



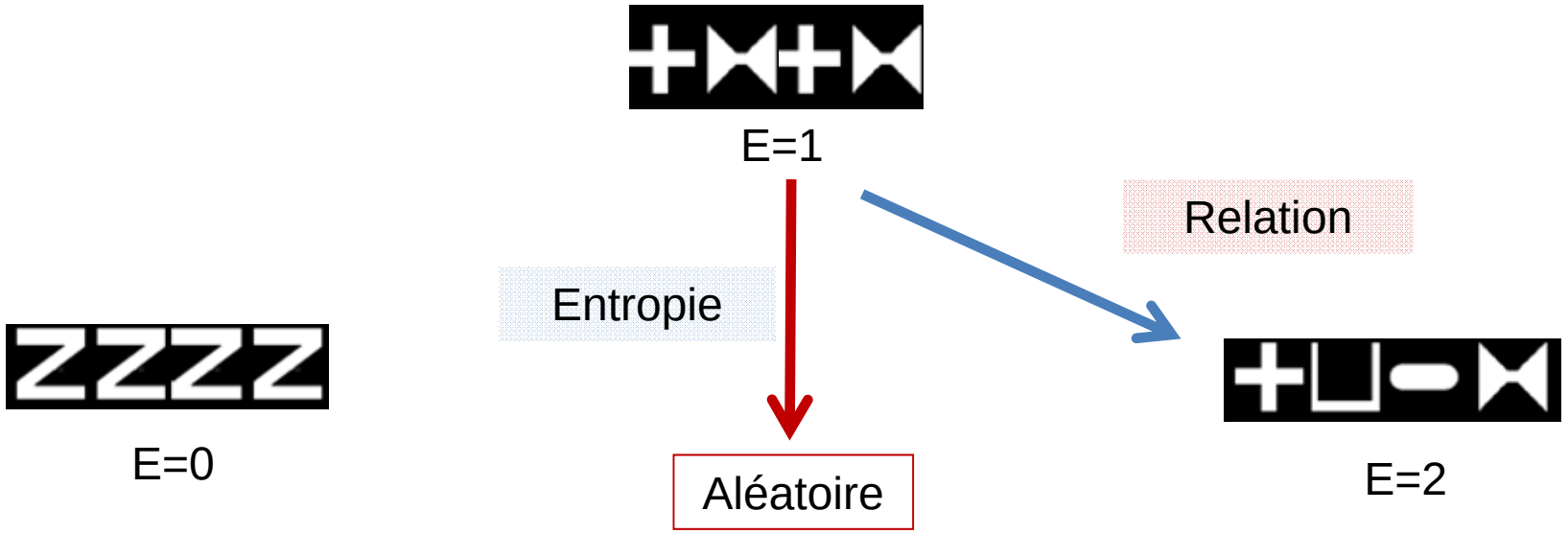
Entropie

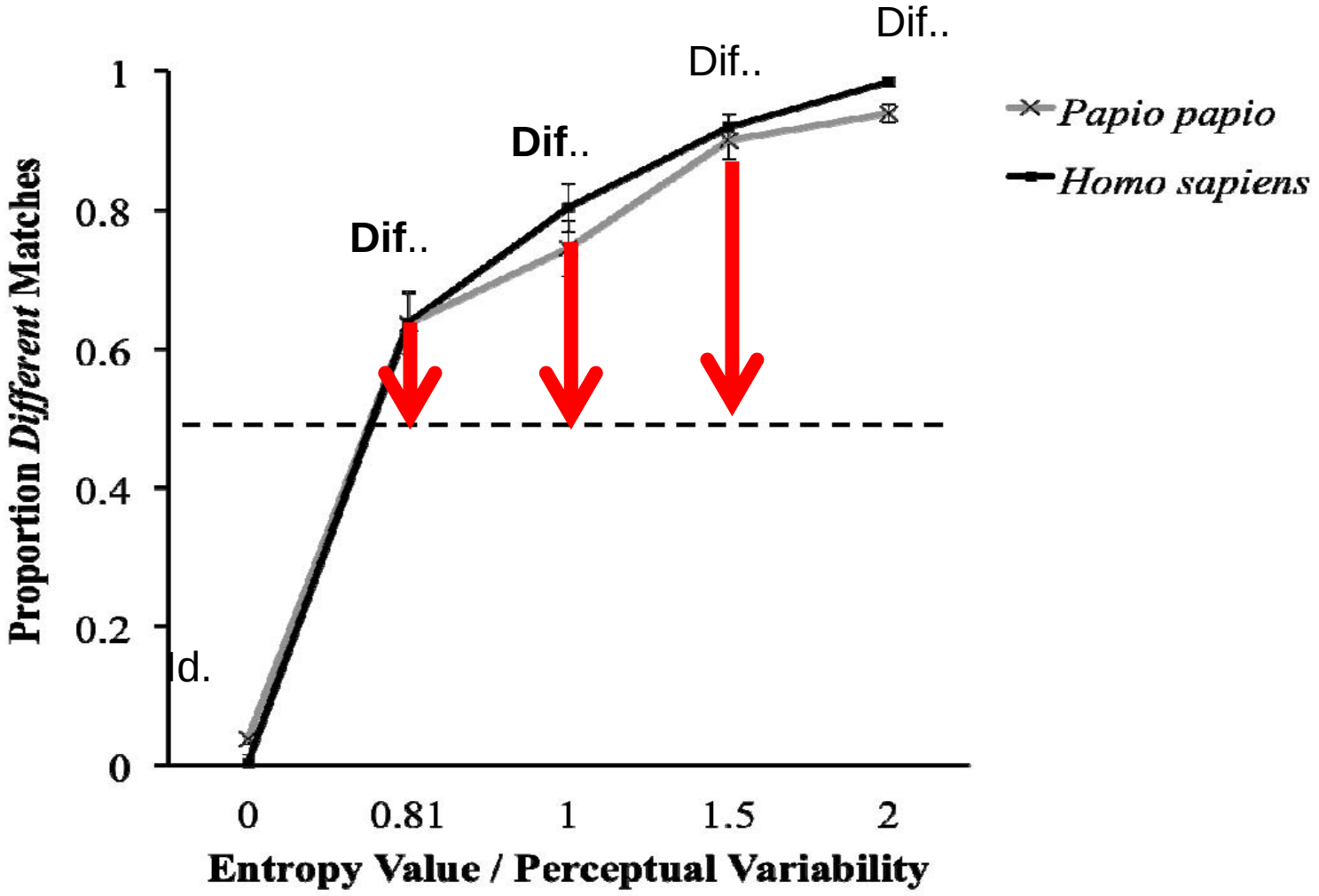
E=0 | E=.81 | E=1 | E=1.5 | E=2



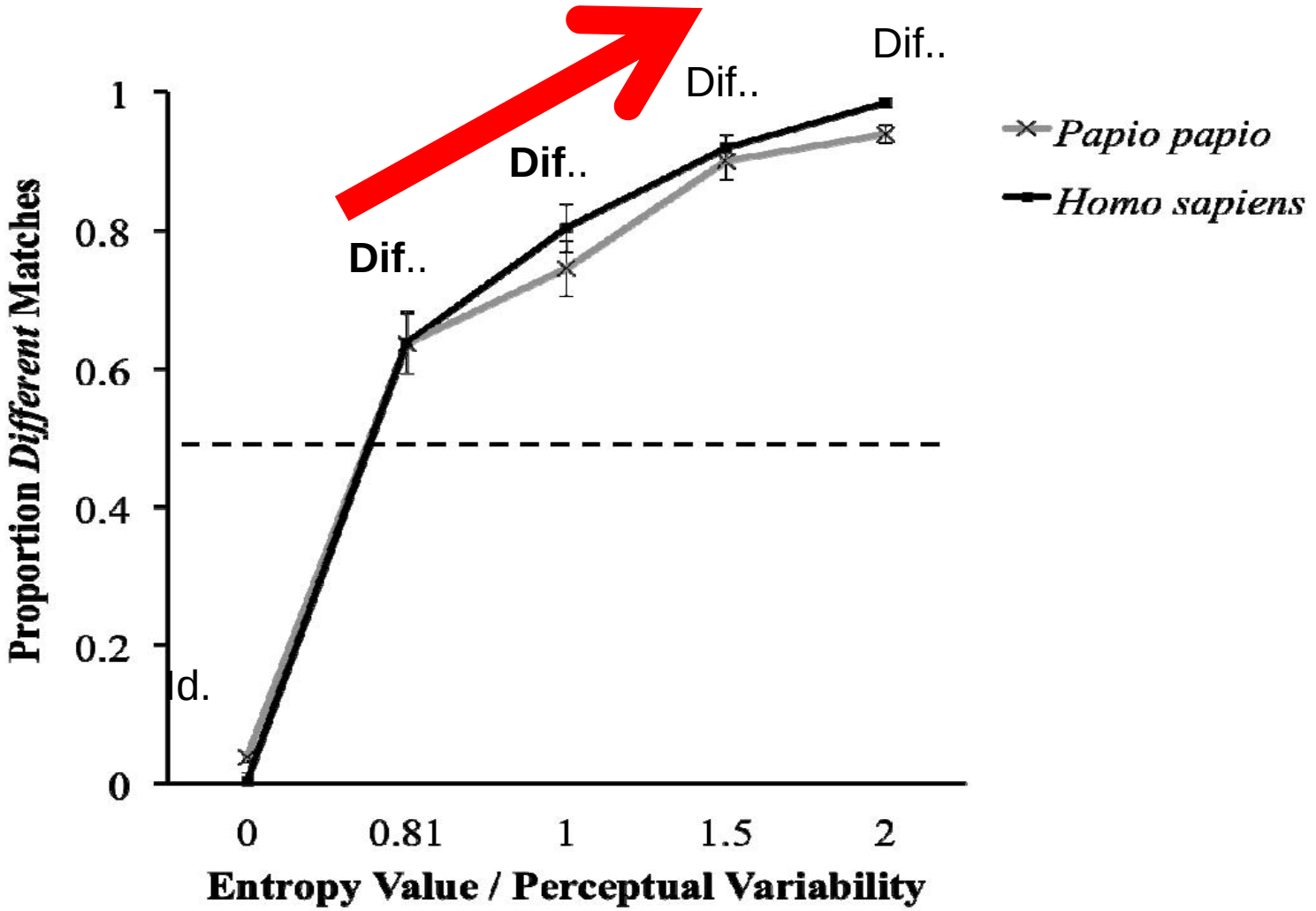
Identique | Différent

Flemming, Thompson & Fagot, Animal Cognition, 2013

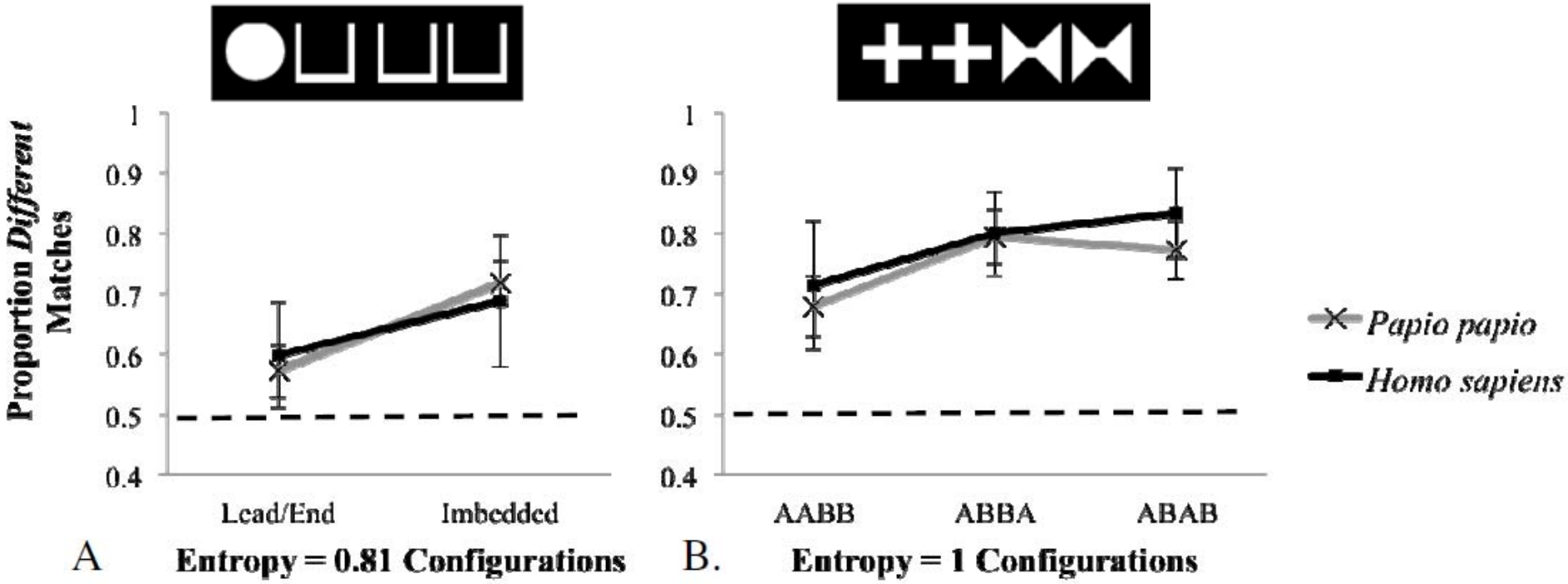

E=1
Relation
Entropie
E=0
Aléatoire
E=2



Stratégie relationnelle



Influence perceptive



Flemming, Thompson & Fagot, Animal Cognition, 2013

Résumé

Traitement prioritaire des informations relationnelles:

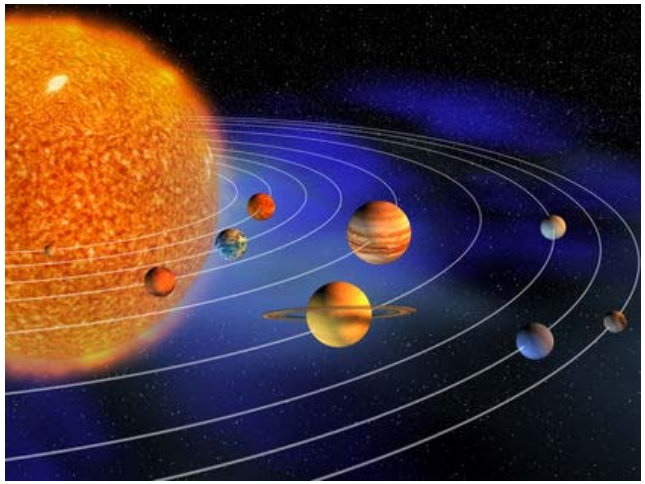
Stratégie « relationnelle »

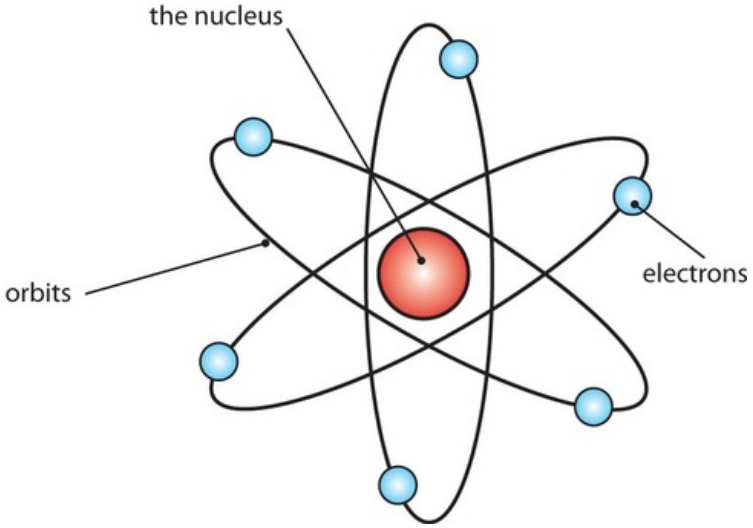
Traitement secondaire des informations perceptives

Différence de complexité

A A

B B C D





« La structure de l’atome ressemble à celle du système solaire »

Analogie

Domaine source

Domaine cible

Sélection des informations pertinentes

Solution

App. relationnel

Paire modèle

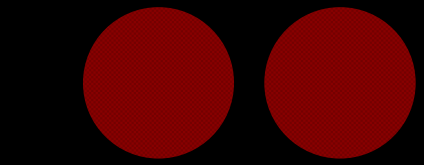
Identifie la relation

reconnait la relation

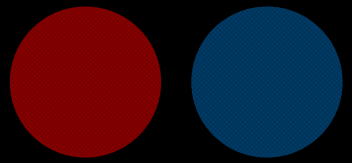
Solution

Tâche d’appariement relationnel bidimensionnelle

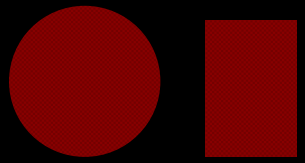
Paires « consistantes »



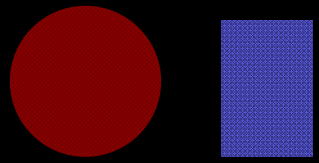
Même couleur
Même forme



Différentes couleurs
Même forme

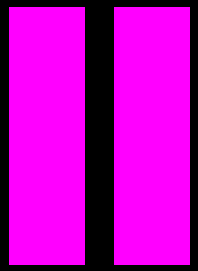


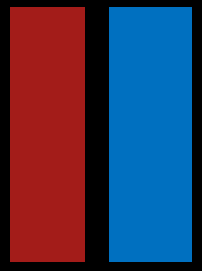
Même couleur
Formes différentes



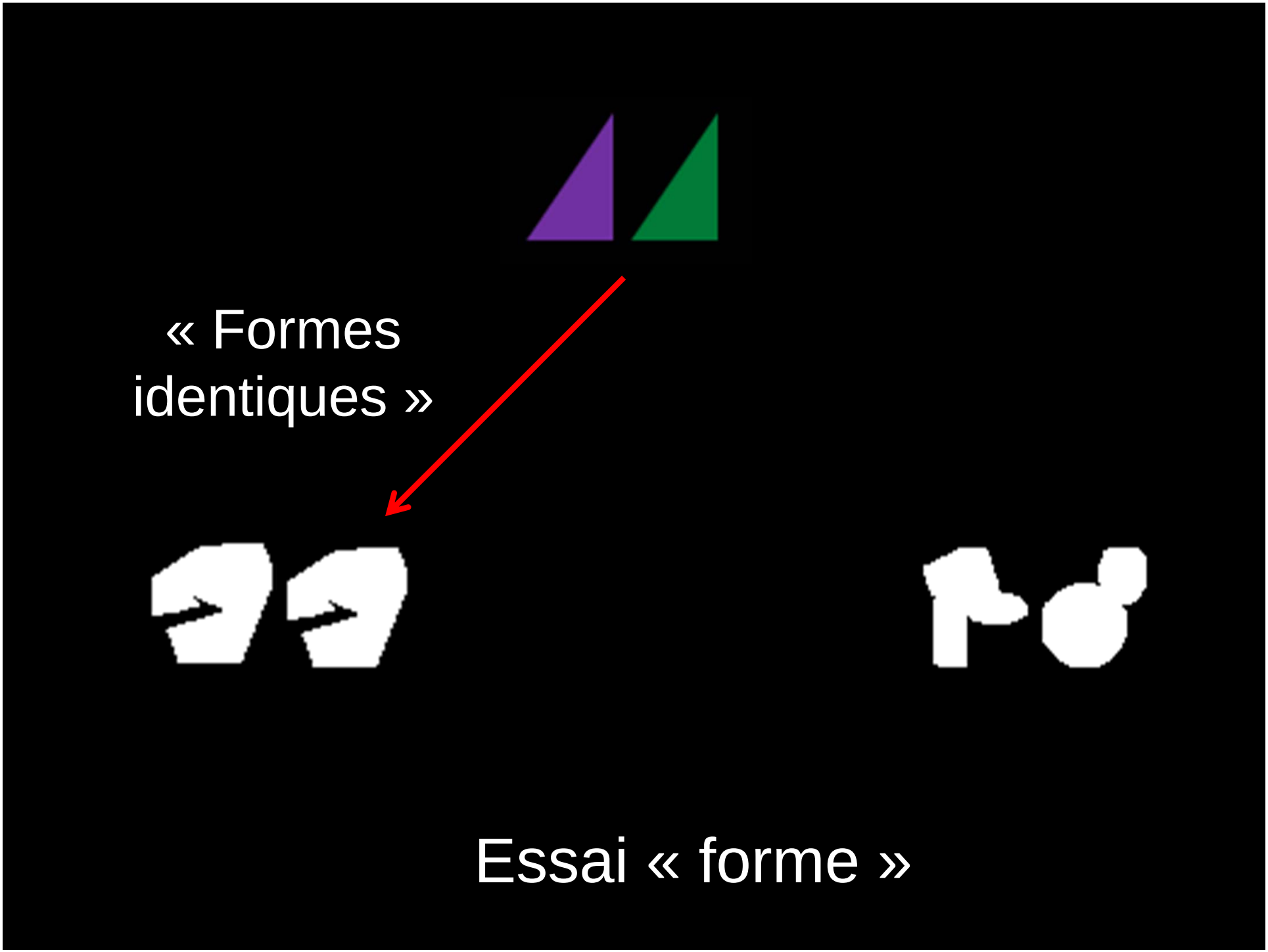
Différentes couleurs
Différentes formes

« Couleurs différentes »





Essai « couleur »


« Formes identiques »
Essai « forme »

Procédure

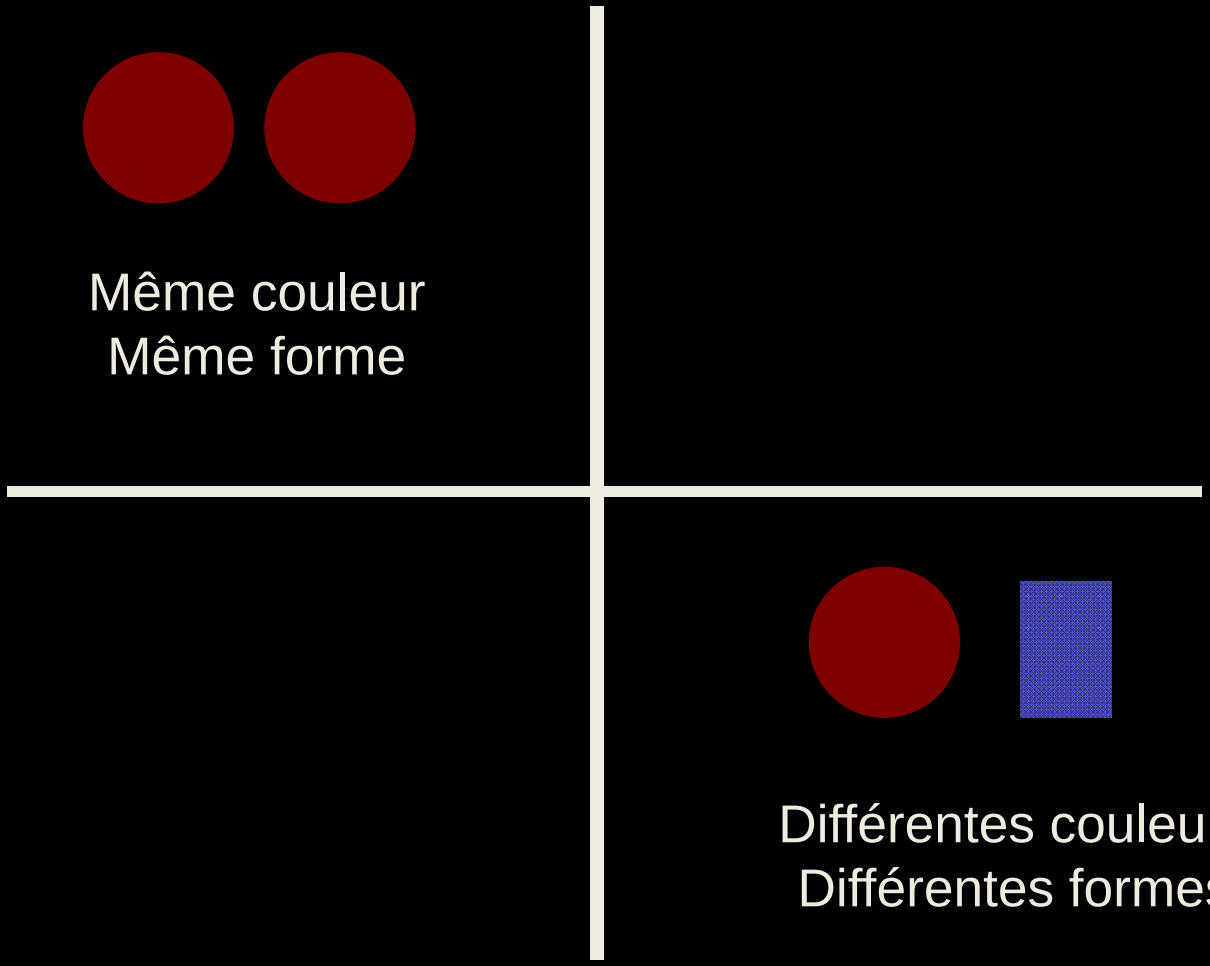
Table 1 Numbers of training blocks performed by each subject as a function of block size (from 120- to 2-trial blocks) for each type of trial (color and shape), as well as total numbers of trials and the corresponding standard deviations (*SD*s) per subject and trial type

Block Size	120	80	40	16	8	4	2	Total Trials
	Color Blocks							
CAUET	141	128	30	17	206	216	86	31,316
DAN	80	169	13	26	284	158	125	27,210
DREAM	146	27	9	10	146	134	124	22,152
VIVIEN	104	190	44	47	212	224	139	33,062
Mean	117.75	128.5	24	25	212	183	118.5	28,435
SD	31.37	72.40	16.15	16.06	56.50	43.95	22.72	4,854.07
	Shape Blocks							
CAUET	199	90	30	27	196	187	55	35,138
DAN	163	84	20	17	278	177	64	30,412
DREAM	92	31	19	23	107	161	50	16,248
VIVIEN	117	232	44	19	302	361	52	38,628
Mean	142.75	109.25	28.25	21.5	220.75	221.5	55.25	30,106.5
SD	47.65	86.02	11.62	4.43	88.38	93.61	6.19	9,833.33

Fagot & Maugard, Learning and Behavior, 2013

Fagot & Maugard, Learning and Behavior, 2013

Essais consistants



Même couleur
Même forme

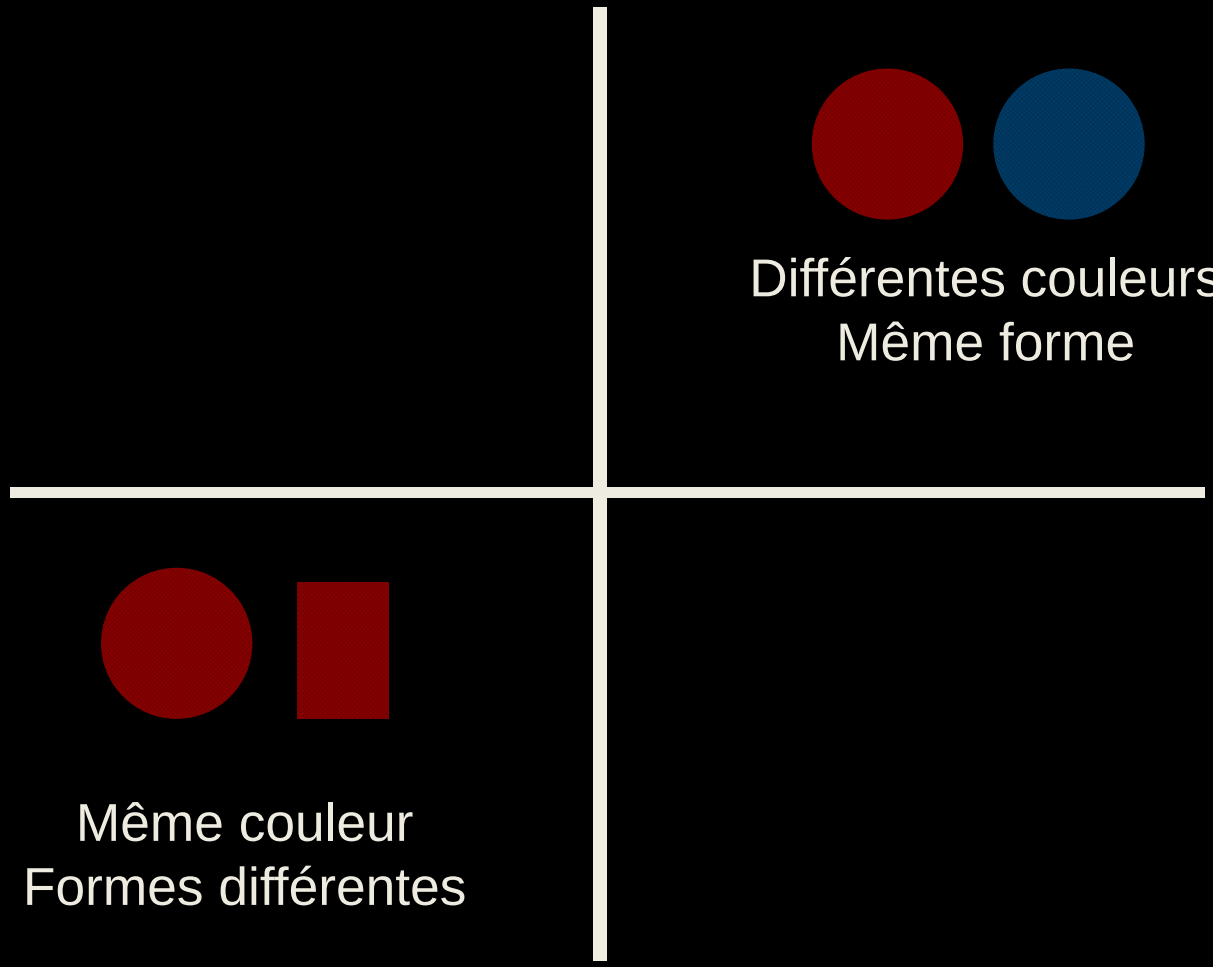
Différentes couleurs
Différentes formes

	Consistent		Inconsistent	
	Color Trials	Shape Trials	Color Trials	Shape Trials
CAUET	**96.43**	**98.81**		
DAN	**89.88**	**94.64**		
DREAM	**94.64**	**96.43**		
VIVIEN	**96.43**	**95.24**		
Mean	94.35	96.28		
SD	3.09	1.84		

Reliable performance for each individual, as inferred from Bonferroni-corrected binomial tests, is indicated in bold

Fagot & Maugard, Learning and Behavior, 2013

Essais inconsistants



Différentes couleurs
Même forme

Même couleur
Formes différentes

	Consistent		Inconsistent	
	Color Trials	Shape Trials	Color Trials	Shape Trials
CAUET	**96.43**	**98.81**	56.55	52.98
DAN	**89.88**	**94.64**	**68.45**	**70.24**
DREAM	**94.64**	**96.43**	42.86	**71.43**
VIVIEN	**96.43**	**95.24**	53.57	54.17
Mean	94.35	96.28	55.36	62.20
SD	3.09	1.84	10.53	9.99

Reliable performance for each individual, as inferred from Bonferroni-corrected binomial tests, is indicated in bold

Fagot & Maugard, Learning and Behavior, 2013

Conclusions

La tâche d'appariement relationnel est accessible aux singes non anthropoïdes (non entraînés à labelliser)

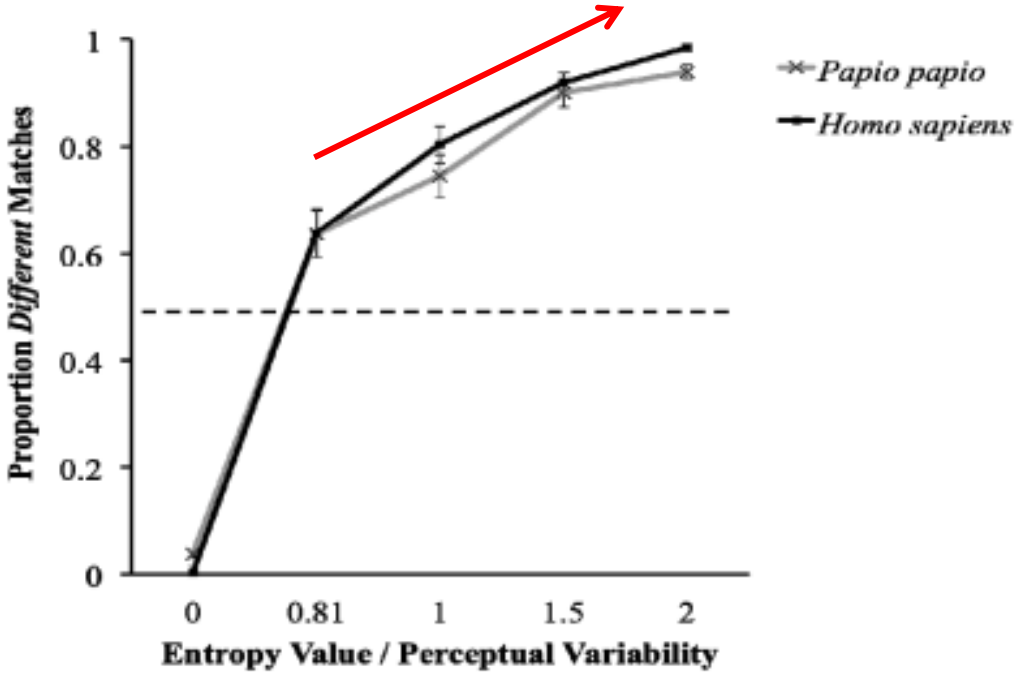
Truppa et al, Plos One, 2012

Wasserman et al., Current Biol., 2014

Traitement relationnel

Donne priorité aux informations relationnelles (e.g., dans les essais « cross-mapped »)

Traitement complémentaire d'informations perceptives



L’appariement relationnel - sans entraînement à la labellisation- requiert un entraînement intensif

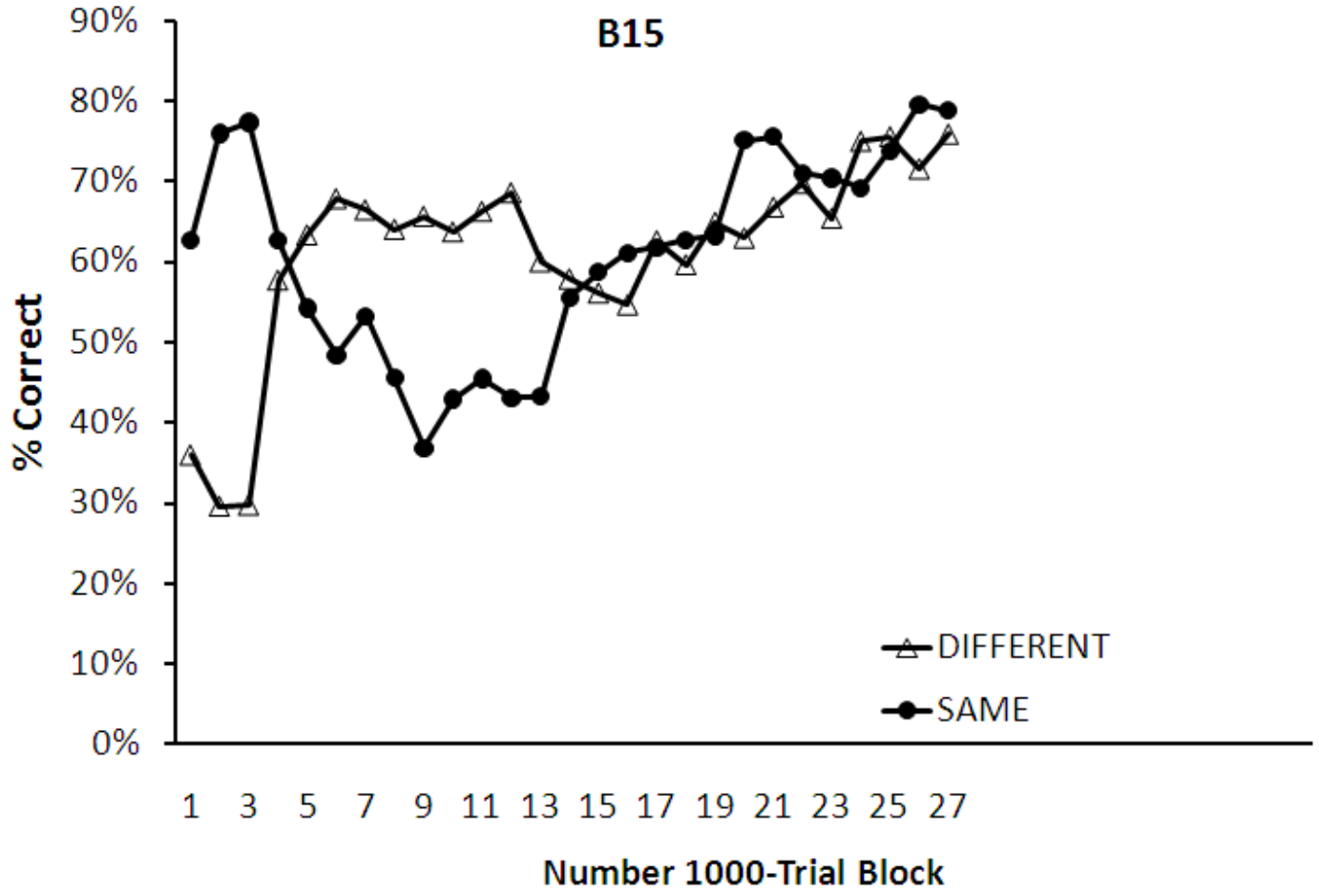
Quel est l’effet de l’entraînement, comparativement aux situations impliquant une labellisation chez l’enfant?

La labellisation “invites comparison”
(Gentner /Waxman)

L’entraînement aussi !!!
(renforcement différentiel)

Les relations d’identité et de différence sont mutuellement exclusives

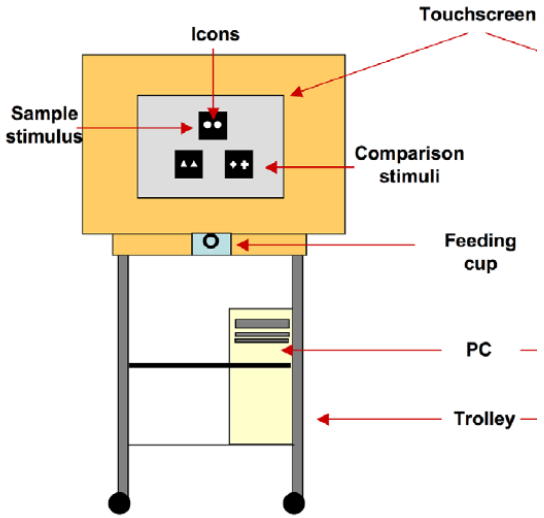
Identique -> non différent
Différent -> non identique

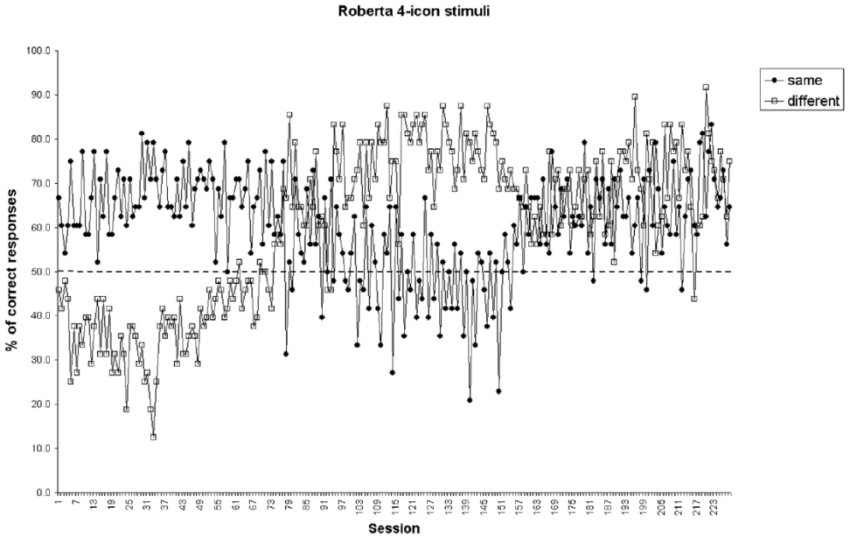


Courbes d’apprentissage

Same/Different Concept Learning by Capuchin Monkeys in Matching-to-Sample Tasks

Valentina Truppa[1,2*], Eva Piano Mortari[1,3], Duilio Garofoli[1,3], Sara Privitera[1,3], Elisabetta Visalberghi[1]





Limites...

La labellisation fournit un mode d'encodage

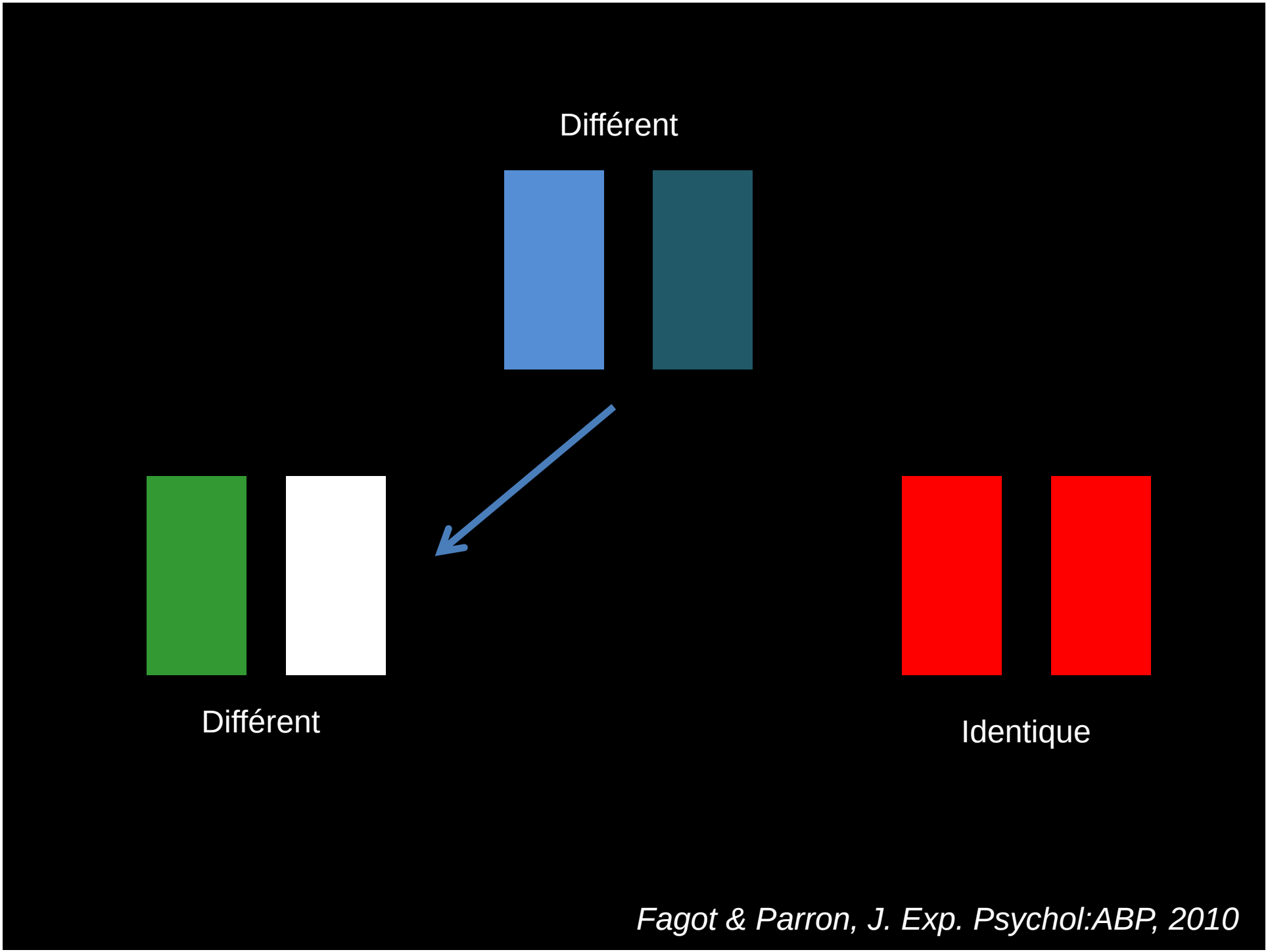
L'entraînement du babouin n'en fournit pas !!!

Limitation probable des capacités de généralisation

Table 1. Demographic Information and Experimental Data for the Subjects in Experiment 1

Baboon	Test location	Gender	Age (years)	Number of training sessions	Mean percentage of correct responses
DRE	Rousset	Female	1.6	179	81.3*
CAU	Rousset	Male	1.9	154	81.7*
CLO	Rousset	Male	2.1	321	81.0*
BAR	Rousset	Male	2.7	169	80.0*
ARI	Rousset	Female	3.4	406	65.6
ART	Rousset	Male	3.4	222	76.6
BOB	Rousset	Male	3.4	179	84.7*
ANG	Rousset	Female	3.8	302	61.7
VIO	Rousset	Female	4.2	376	61.7
VIV	Rousset	Male	4.4	241	72.0
VAN	Rousset	Female	4.7	239	53.3
URA	Rousset	Female	5.2	181	51.0
TAR	Rousset	Female	6.7	337	49.3
ROM	Rousset	Female	8.9	93	49.7
PIP	Rousset	Male	10.4	32	49.7
ATM	Rousset	Female	11	165	49.3
MON	Rousset	Female	12	55	51.3
LEA	Rousset	Female	13.1	75	50.0
MIC	Rousset	Female	13.1	105	51.0
KAL	Rousset	Female	13.5	48	50.3
BRI	Rousset	Female	23.8	130	49.7
B03	Marseille	Male	24	150	52.7
B05	Marseille	Male	24	203	56.0
B06	Marseille	Female	24	129	57.7
B07	Marseille	Male	24	157	69.3
B08	Marseille	Female	24	209	51.7
B11	Marseille	Male	24	198	60.3
B15	Marseille	Male	24	270	81.3*
MIL	Rousset	Male	32.2	126	50.0

Fagot & Thompson, Psychological Science, 2011



Fagot & Parron, J. Exp. Psychol:ABP, 2010

Table 1. Demographic Information and Experimental Data for the Subjects in Experiment 1

Baboon	Test location	Gender	Age (years)	Number of training sessions	Mean percentage of correct responses	
DRE	Rousset	Female	1.6	179	81.3*	Formes
CAU	Rousset	Male	1.9	154	81.7*	
CLO	Rousset	Male	2.1	321	81.0*	
BAR	Rousset	Male	2.7	169	80.0*	
ARI	Rousset	Female	3.4	406	65.6	
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MON	Rousset	Female	12	55	51.3	
LEA	Rousset	Female	13.1	75	50.0	
MIC	Rousset	Female	13.1	105	51.0	
KAL	Rousset	Female	13.5	48	50.3	
BRI	Rousset	Female	23.8	130	49.7	
B03	Marseille	Male	24	150	52.7	
B05	Marseille	Male	24	203	56.0	Couleurs
B06	Marseille	Female	24	129	57.7	
B07	Marseille	Male	24	157	69.3	
B08	Marseille	Female	24	209	51.7	
B11	Marseille	Male	24	198	60.3	
B15	Marseille	Male	24	270	81.3*	Formes
MIL	Rousset	Male	32.2	126	50.0	

Quelles que soient les limites

Cognition relationnelle de haut niveau

Remerciements

- Edward Wasserman, Iowa University
- Michael Young, Southern Illinois University.
- Timothy Fleming, LRC, Atlanta
- Roger Thompson, Franklin & Marshall College
- Anais Maugard, LPC, Marseille

- Personnel de la station de primatologie


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