# IFT609 – INFORMATIQUE COGNITIVE

Rapport de projet



Université de Sherbrooke

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### 1. Introduction

#### 1.1 Domaine

Nous avons choisi d'aborder le thème de la cuisine pour ce projet. En effet, c'est non seulement une activité qui nous unit tous mais également qui fait partie intégrante de notre quotidien. Dans le vaste univers culinaire, nous avons spécifiquement sélectionné le fait de monter les blancs d'œufs en neige car c'est une tâche en apparence simple mais qui est, finalement, loin d'être évidente à maîtriser pour la réussir à tous les coups.

#### 1.2 Problématique

« Monter les blancs en neige » est donc la tâche que nous avons choisi de modéliser. L'idée est d'obtenir une texture parfaite de blanc d'œufs en neige, c'est-à-dire qui soit ferme, non liquide, avec une couleur proche du blanc et un aspect très aéré. Nous pourrons alors jouer sur plusieurs paramètres tels que la vitesse pour fouetter les blancs, le geste utilisé et le temps passé à fouetter. Afin qu'il soit le plus proche possible d'un comportement humain, notre modèle ne pourra pas fouetter à une vitesse trop élevée ni pendant trop longtemps. C'est pourquoi nous avons décidé de prendre en compte la fatigue accumulée au cours du temps.

Nous avons également défini des hypothèses de départ, que l'on va considérer comme étant admises pour la suite, ce qui évitera de trop complexifier notre modèle :

- Tous les ingrédients et ustensiles sont à disposition
- Le plan de travail est en place, prêt à être utilisé
- Notre modèle sait compter

# 2. Représentation des connaissances

#### 2.1 Buts

#### 2.1.1 But principal

Le but principal de notre modèle est d'obtenir des blancs en neige. Pour l'atteindre, celui-ci doit réaliser deux sous-buts : n'avoir que des blancs d'œufs et les battre jusqu'à obtention de la texture souhaitée. Notre modèle, au départ, dispose d'un certain nombre d'œufs à battre ainsi que d'une réserve d'énergie qui va décroître au fil du temps. Si la texture parfaite n'est pas obtenue avant que l'énergie ne tombe à 0, le modèle échoue à atteindre son but principal et s'arrête.

#### **But principal**:

# (chunk-type butAvoirBlancsEnNeige statut)

#### 2.1.2 Sous-buts

Notre premier sous-but est l'obtention de blancs d'œufs uniquement. Lors de ce sous-but, il va non seulement falloir casser les œufs dans le récipient mais également les séparer pour ne conserver que le blanc. Lors de cette opération, il est probable que certains résidus de coquilles et de jaune se

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retrouvent mêlés à nos blancs, il faut donc prendre en compte, si besoin, le nettoyage du mélange avant de passer au sous-but suivant.

#### Premier sous-but:

# (chunk-type butAvoirBlancs nbBlancs nbJaunes nbCoquilles statut)

Une fois ce sous-but réalisé, nos blancs sont en place dans le récipient et nettoyés d'éventuels résidus de coquilles ou de jaune. Notre modèle va pouvoir les battre pour obtenir l'aspect en neige. Obtenir une texture en neige est donc notre second sous-but. Différents paramètres vont alors entrer en jeu pour prendre en compte la vitesse d'exécution, le geste réalisé et le temps passé à fouetter. C'est à partir de ce sous-but que l'énergie disponible dans le but principal va commencer à décroître.

#### Second sous-but:

(chunk-type butObtenirTexture couleurActuelle volumeActuel vitesseActuelle energie statut)

#### 2.2 Types de chunks

#### 2.2.1 La texture

Ce chunk texture correspond à la texture parfaite de blancs en neige que l'on souhaite atteindre. Elle est caractérisée par une couleur proche du blanc, une certaine consistance ainsi qu'une densité. Ces deux derniers paramètres nous permettent d'indiquer les critères d'une texture ferme et aérée.

#### Texture:

# (chunk-type texture couleur volume)

#### 2.2.2 L'expérience de fouettage

L'expérience de fouettage enregistre toutes les tentatives de notre modèle pour monter les blancs en neige lors d'un run. C'est ce chunk qui va lui permettre un apprentissage, en essayant à chaque tentative de tendre vers le chunk texture, énoncé précédemment comme la texture parfaite à obtenir. Pour modéliser cela, nous avons choisi d'enregistrer la texture obtenue par notre modèle en fonction de la couleur actuelle, du volume actuel mais aussi de la vitesse d'exécution et du résultat obtenu.

#### <u>Expérience</u>:

(chunk-type experienceFouettage couleurActuelle volumeActuel vitesseMouvement resultat)

#### 2.3 Procédures

#### 2.3.1 startCassage

Cette procédure va permettre d'amorcer le cassage des œufs lors du démarrage du programme si butAvoirBlancs est le but sélectionné et si son statut est startCassage. Elle déclenche donc la recherche d'œuf à casser.

#### 2.3.2 attraperOeuf

Avant de casser des œufs, le modèle va visuellement les chercher dans la fenêtre graphique. Une fois l'œuf trouvé, il place son curseur dessus et change le statut du goal sur *oeufAttrape* pour simuler le geste de prendre l'œuf et le casser dans le récipient.

#### 2.3.3 casserOeufSansCoquille ou casserOeufAvecCoquille

L'une ou l'autre de ces procédures s'exécute selon l'habitude du modèle : s'il est débutant en cassage d'œufs, le risque de mettre de la coquille dans la préparation est plus grand qu'une fois le geste répété et acquis. Cela nous permet de faire un premier apprentissage via l'habitude en récompensant le modèle lorsqu'il ne met pas de coquille dans la solution. Ainsi, s'il rate son geste, c'est casserOeufAvecCoquille qui s'exécute pour mettre des coquilles dans la préparation et casserOeufSansCoquille sinon. Dans tous les cas, il passe ensuite à la séparation du jaune et du blanc.

#### 2.3.4 separerOeufSansJaune ou separerOeufAvecJaune

Le principe de ces deux procédures est le même que pour les coquilles.

#### 2.3.5 verifierPasCoquille

Cette procédure va permettre au modèle de savoir s'il y a, ou non, des coquilles dans la préparation. S'il n'y en a pas, il va pouvoir vérifier la présence de jaune.

#### 2.3.6 verifierAvecCoquille, retirerCoquille puis retirerCoquilleTermine

La procédure *verifierAvecCoquille* va indiquer au modèle qu'il y a des coquilles dans la préparation et qu'il faut donc la nettoyer pour les retirer avant de passer à la vérification de la présence de jaune. C'est ainsi que *retirerCoquille* s'enclenche, permettant donc de retirer toutes les coquilles. La procédure *retirerCoquilleTermine* va ensuite permettre de passer à la vérification des jaunes.

#### 2.3.7 verifierPasJaune

Cette procédure teste la non-présence de jaune dans la solution et permet de recommencer le processus de cassage d'œufs.

#### 2.3.8 verifierAvecJaune, retirerJaune et retirerJauneTermine

Le principe de ces procédures est le même que pour les coquilles.

#### 2.3.9 passerAuFouettage puis demarrerFouettage

Cette procédure teste s'il n'y a plus aucun œuf à casser pour ensuite commencer le processus de fouettage. Concrètement, elle change le but en cours de traitement de *goalAvoirBlancs* à *goalObtenirTexture*.

#### 2.3.10 recupererVitesseSucces

Permet de récupérer la vitesse d'une précédente tentative terminée par un succès.

#### 2.3.11 recupererVitesseSuccesOK ou recupererVitesseSuccesKO

Dans un premier temps, le modèle va essayer de se rappeler d'une expérience passée où il a réussi à obtenir une texture parfaite de blancs en neige. S'il y arrive, il récupère la vitesse de fouettage qu'il avait utilisée. Sinon, il cherchera une expérience ratée.

# 2.3.12 recupererVitesseManqueEnergieOK ou recupererVitesseManqueEnergieKO

Dans le cas où le modèle n'arrive pas à se rappeler une expérience où il a réussi à obtenir des blancs en neige corrects, il va chercher une expérience passée où il n'a pas réussi. La procédure recupererVitesseManqueEnergieOK va s'exécuter s'il arrive à se rappeler d'une précédente expérience où il a échoué. Il va alors récupérer la vitesse qu'il avait appliqué et chercher à la baisser pour réduire sa dépense d'énergie et maximiser ses chances de réussite. Dans le cas où il n'a aucune expérience, le modèle va choisir une vitesse aléatoire comme premier essai.

#### 2.3.13 baisserVitesse ou augmenterVitesse

En fonction du succès de l'expérience récupérée, le modèle va choisir de diminuer la vitesse rappelée ou de l'augmenter pour optimiser au mieux son énergie.

#### 2.3.14 fouetterClassique

Cette procédure représente le fouettage réalisé par le modèle pour monter ses blancs en neige. Elle permet de mettre à jour au fur et à mesure le volume et la couleur de la préparation en fonction de la vitesse d'exécution tout en diminuant l'énergie encore disponible. Ainsi, la texture s'améliore à chaque itération mais, en contrepartie, l'énergie du modèle diminue.

#### 2.3.15 verifierTexture puis comparerTextureOK ou comparerTextureKO

La procédure *verifierTexture* permet au modèle de se rappeler la texture parfaite enregistrée dans la base de connaissances. Ainsi, il va pouvoir se servir de cette information récupérée pour la comparer avec celle qu'il a actuellement dans son récipient. Si cette texture parfaite a été atteinte, le modèle arrête de fouetter et va enregistrer la tentative comme étant un succès. Sinon, il va chercher à continuer de fouetter pour l'atteindre mais devra d'abord s'assurer d'avoir assez d'énergie pour continuer.

#### 2.3.16 verifierEnergieOK ou verifierEnergieKO

Ces procédures permettent au modèle de savoir s'il lui reste encore de l'énergie ou non. Si c'est le cas, il continue le fouettage en exécutant *fouetterClassique*. Sinon, il arrête et selon la valeur de la texture obtenue, la tentative sera un succès ou un échec.

## 2.3.17 finirExperienceEchec ou finirExperienceSucces

Si le modèle a réussi à monter les blancs en neige, *finirExperienceSucces* sera la procédure exécutée. Elle va permettre d'enregistrer cette tentative comme un succès pour que notre modèle puisse apprendre et s'en rappeler plus tard. En revanche, s'il n'a pas réussi, c'est *finirExperienceEchec* qui s'exécutera pour enregistrer cette expérience comme étant ratée. L'enregistrement des valeurs de

couleur, de volume, de vitesse d'exécution et de résultat (échec ou succès) permettront alors au modèle d'adapter son geste pour les itérations futures.

# 3. Exécution du programme

#### 3.1 Scénario simulé

Le scénario que nous présentons dans ce rapport est le cas dans lequel le modèle n'a aucune expérience pour casser, séparer ou fouetter des œufs. Il va donc commencer par chercher les œufs, les attraper puis les casser avec une certaine probabilité de mettre des coquilles dans la solution. Puis, il va séparer le blanc du jaune d'œuf avec une certaine probabilité de mettre un peu de jaune dans la solution. Une fois ces étapes faites pour un œuf, il vérifie si des coquilles ou du jaune auraient été ajoutés à la solution et si oui, il retire les éléments non désirés. Il va répéter ce processus tant qu'il y aura des œufs dans son champ de vision.

Une fois ces étapes de cassage et de séparation effectuées pour tous les œufs, le modèle va passer au fouettage. Dans un premier temps, il va essayer de se rappeler d'une précédente expérience où sa tentative de fouettage des œufs a réussi. S'il y arrive, il utilisera cette vitesse pour fouetter les œufs. S'il ne se rappelle pas d'une tentative réussie, il va chercher une tentative où il n'a pas réussi à obtenir des blancs en neige avant de s'épuiser. Dans ce cas-là, il va réduire sa vitesse pour essayer de moins dépenser d'énergie pour atteindre une texture en neige. S'il n'a absolument aucune expérience, il va prendre une valeur de vitesse aléatoire.

#### 3.2 Trace

```
(experiment)
        0.000
                GOAL
                                         SET-BUFFER-CHUNK GOAL GOALAVOIRBLANCSENNEIGE REQUESTED NIL
        0.000
                                         SET-BUFFER-CHUNK GOAL BUTAVOIRBLANCSENNEIGEØ REOUESTED NIL
                GOAL
        0.000
                VISION
                                         SET-BUFFER-CHUNK VISUAL-LOCATION VISUAL-LOCATION0-0
REQUESTED NIL
        0.000
                PROCEDURAL
                                         CONFLICT-RESOLUTION
                                         PRODUCTION-FIRED START
        0.050
                PROCEDURAL
                                         SET-BUFFER-CHUNK GOAL GOALAVOIRBLANCS REQUESTED NIL
        0.050
                GOAL
        0.050
                PROCEDURAL
                                         CONFLICT-RESOLUTION
        0.100
                PROCEDURAL
                                         PRODUCTION-FIRED STARTCASSAGE
                PROCEDURAL
        0.100
                                         CLEAR-BUFFER VISUAL-LOCATION
        0.100
                VISION
                                         Find-location
                                         SET-BUFFER-CHUNK VISUAL-LOCATION VISUAL-LOCATION2-0
        0.100
                VTSTON
        0.100
                PROCEDURAL
                                         CONFLICT-RESOLUTION
        0.150
                PROCEDURAL
                                         PRODUCTION-FIRED ATTRAPEROEUF
        0.150
                PROCEDURAL
                                         CLEAR-BUFFER VISUAL
        0.150
                PROCEDURAL
                                         CLEAR-BUFFER MANUAL
                                         MOVE-CURSOR LOC VISUAL-LOCATION2-0-0
        0.150
                MOTOR
        0.150
                PROCEDURAL
                                         CONFLICT-RESOLUTION
        0.235
                VISION
                                         Encoding-complete VISUAL-LOCATION2-0-0 NIL
        0.235
                VISION
                                         SET-BUFFER-CHUNK VISUAL TEXT0
        0.235
                PROCEDURAL
                                         CONFLICT-RESOLUTION
                                         CONFLICT-RESOLUTION
        0.350
                PROCEDURAL
        0.400
                PROCEDURAL
                                         CONFLICT-RESOLUTION
        0.581
                PROCEDURAL
                                         CONFLICT-RESOLUTION
        0.631
                PROCEDURAL
                                         CONFLICT-RESOLUTION
                PROCEDURAL
                                         PRODUCTION-FIRED CASSEROEUFAVECCOQUILLE
        0.681
1
        0.681
                PROCEDURAL
                                         CLEAR-BUFFER MANUAL
        0.681
                MOTOR
                                         CLICK-MOUSE
        0.681
                UTTI TTY
                                         PROPAGATE-REWARD 1
```

```
Utility updates with Reward = 1.0 alpha = 0.2
Updating utility of production START
  U(n-1) = 0.0
                R(n) = 0.319 [1.0 - 0.681 seconds since selection]
  U(n) = 0.0638
 Updating utility of production STARTCASSAGE
  U(n-1) = 0.0 R(n) = 0.36900002 [1.0 - 0.631 seconds since selection]
 U(n) = 0.073800005
 Updating utility of production ATTRAPEROEUF
  U(n-1) = 0.0 R(n) = 0.41900003 [1.0 - 0.581 seconds since selection]
 U(n) = 0.08380001
 Updating utility of production CASSEROEUFAVECCOQUILLE
  U(n-1) = 0.0 R(n) = 0.95 [1.0 - 0.05 seconds since selection]
  U(n) = 0.19
      0.681 PROCEDURAL
                                      CONFLICT-RESOLUTION
      0.731 PROCEDURAL
                                      PRODUCTION-FIRED SEPAREROEUFAVECJAUNE
      0.731 UTILITY
                                      PROPAGATE-REWARD 1
Utility updates with Reward = 1.0 alpha = 0.2
 Updating utility of production SEPAREROEUFAVECJAUNE
  U(n-1) = 0.0 R(n) = 0.95 [1.0 - 0.05 seconds since selection]
  U(n) = 0.19
      0.731
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      0.781
              PROCEDURAL
                                      PRODUCTION-FIRED VERIFIERAVECCOOUILLE
      0.781
              PROCEDURAL
                                      CONFLICT-RESOLUTION
              PROCEDURAL
                                      PRODUCTION-FIRED RETIRERCOQUILLE
      0.831
      0.831
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      0.881
              PROCEDURAL
                                      PRODUCTION-FIRED RETIRERCOQUILLETERMINE
      0.881
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      0.891
              MOTOR
                                      OUTPUT-KEY #(28 2)
              PROCEDURAL
                                      PRODUCTION-FIRED VERIFIERAVECJAUNE
      0.931
              PROCEDURAL
      0.931
                                      CLEAR-BUFFER VISUAL
      0.931
              PROCEDURAL
                                      CLEAR-BUFFER MANUAL
      0.931
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      0.976
              VISION
                                      Encoding-complete VISUAL-LOCATION2-0-0 NIL
                                      No visual-object found
      0.976
              VTSTON
                                      PRODUCTION-FIRED RETIRERJAUNE
      0.981
              PROCEDURAL
      0.981
              PROCEDURAL
                                      CONFLICT-RESOLUTION
              PROCEDURAL
      1.031
                                      PRODUCTION-FIRED RETIRERJAUNETERMINE
      1.031
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      1.081
              PROCEDURAL
                                      PRODUCTION-FIRED STARTCASSAGE
      1.081
              PROCEDURAL
                                      CLEAR-BUFFER VISUAL-LOCATION
      1.081
              VISION
                                      Find-location
              VISION
      1.081
                                      SET-BUFFER-CHUNK VISUAL-LOCATION VISUAL-LOCATION4-1
      1.081
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      1.131
              PROCEDURAL
                                      PRODUCTION-FIRED ATTRAPEROEUF
      1.131
              PROCEDURAL
                                      CLEAR-BUFFER VISUAL
      1.131
              PROCEDURAL
                                      CLEAR-BUFFER MANUAL
      1.131
              MOTOR
                                      MOVE-CURSOR LOC VISUAL-LOCATION4-1-0
      1.131
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      1.216
              VISION
                                      Encoding-complete VISUAL-LOCATION4-1-0 NIL
                                      SET-BUFFER-CHUNK VISUAL TEXT1
      1.216
              VISION
              PROCEDURAL
      1.216
                                      CONFLICT-RESOLUTION
                                      CONFLICT-RESOLUTION
      1.331
              PROCEDURAL
      1.381
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      1.493
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      1.543
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      1.593
             PROCEDURAL
                                      PRODUCTION-FIRED CASSEROEUFAVECCOQUILLE
      1.593
              PROCEDURAL
                                      CLEAR-BUFFER MANUAL
      1.593
                                      CLTCK-MOUSE
              MOTOR
      1.593
             UTILITY
                                      PROPAGATE-REWARD 1
Utility updates with Reward = 1.0 alpha = 0.2
Updating utility of production VERIFIERAVECCOQUILLE
  U(n-1) = 0.0 R(n) = 0.13800001 [1.0 - 0.862 seconds since selection]
  U(n) = 0.027600003
 Updating utility of production RETIRERCOQUILLE
 U(n-1) = 0.0 R(n) = 0.18800002 [1.0 - 0.812 seconds since selection]
 U(n) = 0.037600007
 Updating utility of production RETIRERCOQUILLETERMINE
```

```
U(n-1) = 0.0
                R(n) = 0.23799998 [1.0 - 0.762 seconds since selection]
 U(n) = 0.047599997
 Updating utility of production VERIFIERAVECJAUNE
  U(n-1) = 0.0 R(n) = 0.288 [1.0 - 0.712 seconds since selection]
 U(n) = 0.0576
 Updating utility of production RETIRERJAUNE
 U(n-1) = 0.0 R(n) = 0.338 [1.0 - 0.662 seconds since selection]
  U(n) = 0.067600004
 Updating utility of production RETIRERJAUNETERMINE
 U(n-1) = 0.0 R(n) = 0.388 [1.0 - 0.612 seconds since selection]
 U(n) = 0.0776
 Updating utility of production STARTCASSAGE
  U(n-1) = 0.073800005 R(n) = 0.43800002 [1.0 - 0.562 seconds since selection]
  U(n) = 0.14664
 Updating utility of production ATTRAPEROEUF
  U(n-1) = 0.08380001 R(n) = 0.48799998 [1.0 - 0.512 seconds since selection]
 U(n) = 0.16464001
 Updating utility of production CASSEROEUFAVECCOQUILLE
  U(n-1) = 0.19 R(n) = 0.95 [1.0 - 0.05 seconds since selection]
  U(n) = 0.342
      1.593 PROCEDURAL
                                      CONFLICT-RESOLUTION
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              PROCEDURAL
                                      PRODUCTION-FIRED SEPAREROEUFAVECJAUNE
      1.643
              UTILITY
                                       PROPAGATE-REWARD 1
Utility updates with Reward = 1.0 alpha = 0.2
Updating utility of production SEPAREROEUFAVECJAUNE
  U(n-1) = 0.19 R(n) = 0.95 [1.0 - 0.05 seconds since selection]
 U(n) = 0.342
      1.643
             PROCEDURAL
                                       CONFLICT-RESOLUTION
             PROCEDURAL PROCEDURAL
      1.693
                                      PRODUCTION-FIRED VERIFIERAVECCOQUILLE
      1.693
              PROCEDURAL
                                       CONFLICT-RESOLUTION
      1.743
              PROCEDURAL
                                       PRODUCTION-FIRED RETIRERCOQUILLE
      1.743
              PROCEDURAL
                                       CONFLICT-RESOLUTION
      1.793
              PROCEDURAL
                                       PRODUCTION-FIRED RETIRERCOQUILLETERMINE
                                      CONFLICT-RESOLUTION
              PROCEDURAL
      1.793
      1.803
              MOTOR
                                      OUTPUT-KEY #(28 2)
      1.843
              PROCEDURAL
                                      PRODUCTION-FIRED VERIFIERAVECJAUNE
      1.843
              PROCEDURAL
                                      CLEAR-BUFFER VISUAL
      1.843
              PROCEDURAL
                                      CLEAR-BUFFER MANUAL
      1.843
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      1.888
              VISION
                                      Encoding-complete VISUAL-LOCATION4-1-0 NIL
      1.888
              VISION
                                       No visual-object found
      1.893
              PROCEDURAL
                                      PRODUCTION-FIRED RETIRERJAUNE
      1.893
              PROCEDURAL
                                       CONFLICT-RESOLUTION
      1.943
              PROCEDURAL
                                      PRODUCTION-FIRED RETIRERJAUNETERMINE
      1.943
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      1.993
              PROCEDURAL
                                      PRODUCTION-FIRED STARTCASSAGE
                                      CLEAR-BUFFER VISUAL-LOCATION
      1.993
              PROCEDURAL
      1.993
              VISION
                                      Find-location
              VISION
                                      SET-BUFFER-CHUNK VISUAL-LOCATION VISUAL-LOCATION0-2
      1.993
      1.993
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      2.043
              PROCEDURAL
                                      PRODUCTION-FIRED ATTRAPEROEUF
      2.043
              PROCEDURAL
                                      CLEAR-BUFFER VISUAL
       2.043
              PROCEDURAL
                                       CLEAR-BUFFER MANUAL
      2.043
              MOTOR
                                      MOVE-CURSOR LOC VISUAL-LOCATION0-2-0
              PROCEDURAL
      2.043
                                      CONFLICT-RESOLUTION
      2.128
              VISION
                                       Encoding-complete VISUAL-LOCATION0-2-0 NIL
      2.128
              VTSTON
                                      SET-BUFFER-CHUNK VISUAL TEXT2
      2.128
              PROCEDURAL
                                      CONFLICT-RESOLUTION
                                      CONFLICT-RESOLUTION
      2.243
              PROCEDURAL
      2.293
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      2.487
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      2.537
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      2.587
              PROCEDURAL
                                       PRODUCTION-FIRED CASSEROEUFAVECCOQUILLE
      2.587
              PROCEDURAL
                                      CLEAR-BUFFER MANUAL
      2.587
              MOTOR
                                       CLICK-MOUSE
      2.587
                                       PROPAGATE-REWARD 1
              UTILITY
Utility updates with Reward = 1.0 alpha = 0.2
```

```
Updating utility of production VERIFIERAVECCOQUILLE
 U(n-1) = 0.027600003 R(n) = 0.055999994 [1.0 - 0.944 seconds since selection]
  U(n) = 0.03328
 Updating utility of production RETIRERCOQUILLE
 U(n-1) = 0.037600007  R(n) = 0.1060000006 [1.0 - 0.894 seconds since selection]
 U(n) = 0.051280007
 Updating utility of production RETIRERCOQUILLETERMINE
  U(n-1) = 0.047599997 R(n) = 0.15600002 [1.0 - 0.844 seconds since selection]
  U(n) = 0.06928
 Updating utility of production VERIFIERAVECJAUNE
  U(n-1) = 0.0576 R(n) = 0.20599997 [1.0 - 0.794 seconds since selection]
 U(n) = 0.08728
 Updating utility of production RETIRERJAUNE
 U(n-1) = 0.067600004 R(n) = 0.25599998 [1.0 - 0.744 seconds since selection]
 U(n) = 0.10528
 Updating utility of production RETIRERJAUNETERMINE
 U(n-1) = 0.0776 R(n) = 0.306 [1.0 - 0.694 seconds since selection]
  U(n) = 0.12328
 Updating utility of production STARTCASSAGE
 U(n-1) = 0.14664 R(n) = 0.356 [1.0 - 0.644 seconds since selection]
 U(n) = 0.188512
 Updating utility of production ATTRAPEROEUF
  U(n-1) = 0.16464001 R(n) = 0.40600002 [1.0 - 0.594 seconds since selection]
  U(n) = 0.21291201
 Updating utility of production CASSEROEUFAVECCOQUILLE
  U(n-1) = 0.342 R(n) = 0.95 [1.0 - 0.05 seconds since selection]
 U(n) = 0.4636
      2.587
             PROCEDURAL
                                       CONFLICT-RESOLUTION
             PROCEDURAL
                                      PRODUCTION-FIRED SEPAREROEUFAVECJAUNE
      2.637
      2.637 UTILITY
                                       PROPAGATE-REWARD 1
Utility updates with Reward = 1.0 alpha = 0.2
 Updating utility of production SEPAREROEUFAVECJAUNE
  U(n-1) = 0.342 R(n) = 0.95 [1.0 - 0.05 seconds since selection]
  U(n) = 0.4636
      2.637
             PROCEDURAL
                                      CONFLICT-RESOLUTION
      2.687
             PROCEDURAL
                                       PRODUCTION-FIRED VERIFIERAVECCOQUILLE
      2.687
              PROCEDURAL
                                      CONFLICT-RESOLUTION
              PROCEDURAL
                                       PRODUCTION-FIRED RETIRERCOQUILLE
      2.737
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      2.737
      2.787
              PROCEDURAL
                                       PRODUCTION-FIRED RETIRERCOQUILLETERMINE
       2.787
              PROCEDURAL
                                       CONFLICT-RESOLUTION
                                      <u>OUTPUT-KEY</u> #(28 2)
      2.797
              MOTOR
      2.837
              PROCEDURAL
                                       PRODUCTION-FIRED VERIFIERAVECJAUNE
              PROCEDURAL
                                      CLEAR-BUFFER VISUAL
      2.837
      2.837
              PROCEDURAL
                                      CLEAR-BUFFER MANUAL
      2.837
              PROCEDURAL
                                      CONFLICT-RESOLUTION
              VISION
      2.882
                                      Encoding-complete VISUAL-LOCATION0-2-0 NIL
              VISION
                                       No visual-object found
      2.882
              PROCEDURAL
                                      PRODUCTION-FIRED RETIRERJAUNE
      2.887
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      2.887
      2.937
              PROCEDURAL
                                       PRODUCTION-FIRED RETIRERJAUNETERMINE
      2.937
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      2.987
              PROCEDURAL
                                       PRODUCTION-FIRED STARTCASSAGE
                                      CLEAR-BUFFER VISUAL-LOCATION
      2.987
              PROCEDURAL
      2.987
              VISION
                                      Find-location
      2.987
              VISION
                                      SET-BUFFER-CHUNK VISUAL-LOCATION VISUAL-LOCATION6-3
              PROCEDURAL
      2.987
                                      CONFLICT-RESOLUTION
       3.037
              PROCEDURAL
                                      PRODUCTION-FIRED ATTRAPEROEUF
              PROCEDURAL
                                      CLEAR-BUFFER VISUAL
      3.037
      3.037
              PROCEDURAL
                                      CLEAR-BUFFER MANUAL
      3.037
              MOTOR
                                      MOVE-CURSOR LOC VISUAL-LOCATION6-3-0
      3.037
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      3.122
              VISION
                                       Encoding-complete VISUAL-LOCATION6-3-0 NIL
                                       SET-BUFFER-CHUNK VISUAL TEXT3
      3.122
              VISION
      3.122
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      3.237
              PROCEDURAL
                                       CONFLICT-RESOLUTION
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      3.287
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      3.533
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3.583
              PROCEDURAL
                                      CONFLICT-RESOLUTION
       3.633
              PROCEDURAL
                                      PRODUCTION-FIRED CASSEROEUFAVECCOQUILLE
              PROCEDURAL
                                      CLEAR-BUFFER MANUAL
      3.633
      3.633
             MOTOR
                                      CLICK-MOUSE
      3.633 UTILITY
                                      PROPAGATE-REWARD 1
Utility updates with Reward = 1.0 alpha = 0.2
 Updating utility of production VERIFIERAVECCOQUILLE
  U(n-1) = 0.03328 R(n) = 0.004000008 [1.0 - 0.996 seconds since selection]
 U(n) = 0.027424002
 Updating utility of production RETIRERCOQUILLE
 U(n-1) = 0.051280007
                       R(n) = 0.05400002 [1.0 - 0.946 seconds since selection]
  U(n) = 0.05182401
 Updating utility of production RETIRERCOQUILLETERMINE
 U(n-1) = 0.06928 R(n) = 0.10399997 [1.0 - 0.896 seconds since selection]
 U(n) = 0.07622399
 Updating utility of production VERIFIERAVECJAUNE
  U(n-1) = 0.08728 R(n) = 0.15399998 [1.0 - 0.846 seconds since selection]
 U(n) = 0.100623995
 Updating utility of production RETIRERJAUNE
  U(n-1) = 0.10528 R(n) = 0.204 [1.0 - 0.796 seconds since selection]
 U(n) = 0.12502399
 Updating utility of production RETIRERJAUNETERMINE
  U(n-1) = 0.12328  R(n) = 0.254 [1.0 - 0.746 seconds since selection]
 U(n) = 0.149424
 Updating utility of production STARTCASSAGE
 U(n-1) = 0.188512 R(n) = 0.30400002 [1.0 - 0.696 seconds since selection]
  U(n) = 0.2116096
 Updating utility of production ATTRAPEROEUF
 U(n-1) = 0.21291201 R(n) = 0.35399997 [1.0 - 0.646 seconds since selection]
 U(n) = 0.2411296
 Updating utility of production CASSEROEUFAVECCOQUILLE
  U(n-1) = 0.4636 R(n) = 0.95 [1.0 - 0.05 seconds since selection]
  U(n) = 0.56088
      3.633 PROCEDURAL
                                      CONFLICT-RESOLUTION
      3.683
             PROCEDURAL
                                      PRODUCTION-FIRED SEPAREROEUFSANSJAUNE
      3.683 UTILITY
                                      PROPAGATE-REWARD 3
Utility updates with Reward = 3.0 alpha = 0.2
 Updating utility of production SEPAREROEUFSANSJAUNE
 U(n-1) = 0.0 R(n) = 2.95 [3.0 - 0.05 seconds since selection]
  U(n) = 0.590000003
      3.683 PROCEDURAL
                                      CONFLICT-RESOLUTION
      3.733
              PROCEDURAL
                                      PRODUCTION-FIRED VERIFIERAVECCOQUILLE
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      3.733
      3.783
              PROCEDURAL
                                      PRODUCTION-FIRED RETIRERCOQUILLE
      3.783
              PROCEDURAL
                                      CONFLICT-RESOLUTION
              PROCEDURAL
                                      PRODUCTION-FIRED RETIRERCOQUILLETERMINE
      3.833
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      3.833
                                      OUTPUT-KEY #(28 2)
      3.843
              MOTOR
      3.883
              PROCEDURAL
                                      PRODUCTION-FIRED VERIFIERPASJAUNE
      3.883
              PROCEDURAL
                                      CLEAR-BUFFER VISUAL
      3.883
              PROCEDURAL
                                      CLEAR-BUFFER MANUAL
       3.883
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      3.928
              VISION
                                      Encoding-complete VISUAL-LOCATION6-3-0 NIL
      3.928
              VISION
                                      No visual-object found
      3.933
              PROCEDURAL
                                      PRODUCTION-FIRED STARTCASSAGE
              PROCEDURAL
      3.933
                                      CLEAR-BUFFER VISUAL-LOCATION
                                      Find-location
       3.933
              VISION
      3.933
              VISION
                                      FIND-LOC-FAILURE
      3.933
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      3.983
              PROCEDURAL
                                      PRODUCTION-FIRED PASSERAUFOUETTAGE
      3.983
              GOAL
                                      SET-BUFFER-CHUNK GOAL GOALAVOIRBLANCSENNEIGE REQUESTED NIL
      3.983
              PROCEDURAL
                                      CLEAR-BUFFER VISUAL-LOCATION
      3.983
              PROCEDURAL
                                      CONFLICT-RESOLUTION
      4.033
              PROCEDURAL
                                      PRODUCTION-FIRED DEMARRERFOUETTAGE
      4.033
              GOAL
                                      SET-BUFFER-CHUNK GOAL GOALOBTENIRTEXTURE REQUESTED NIL
      4.033
              PROCEDURAL
                                      CLEAR-BUFFER VISUAL
              PROCEDURAL
                                      CLEAR-BUFFER MANUAL
      4.033
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4.933 PROCEDURAL 4.983 PROCEDURAL 4.983 PROCEDURAL 4.983 PROCEDURAL 4.983 PROCEDURAL 4.983 PROCEDURAL 4.983 DECLARATIVE 4.983 PROCEDURAL 4.133 PROCEDURAL 4.134 PROCEDURAL 4.135 PROCEDURAL 4.136 PROCEDURAL 4.137 PROCEDURAL 4.138 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.130 PROCEDURAL 4.130 PROCEDURAL 4.131 PROCEDURAL 4.132 PROCEDURAL 4.133 PROCEDURAL 4.134 PROCEDURAL 4.135 PROCEDURAL 4.136 PROCEDURAL 4.137 PROCEDURAL 4.138 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.130 PROCEDURAL 4.130 PROCEDURAL 4.131 PROCEDURAL 4.132 PROCEDURAL 4.133 PROCEDURAL 4.134 PROCEDURAL 4.135 PROCEDURAL 4.136 PROCEDURAL 4.137 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.130 PROCEDURAL 4.131 PROCEDURAL 4.131 PROCEDURAL 4.132 PROCEDURAL 4.133 PROCEDURAL 4.134 PROCEDURAL 4.135 PROCEDURAL 4.136 PROCEDURAL 4.137 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.130 PROCEDURAL 4.131 PROCEDURAL 4.131 PROCEDURAL 4.132 PROCEDURAL 4.133 PROCEDURAL 4.134 PROCEDURAL 4.135 PROCEDURAL 4.136 PROCEDURAL 4.137 PROCEDURAL 4.138 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.130 PROCEDURAL 4.131 PROCEDURAL 4.131 PROCEDURAL 4.132 PROCEDURAL 4.133 PROCEDURAL 4.134 PROCEDURAL 4.135 PROCEDURAL 4.136 PROCEDURAL 4.137 PROCEDURAL 4.138 PROCEDURAL 4.139				
4.083 PROCEDURAL 4.083 DECLARATIVE 5. START-RETREVAL 6. START-RETR	4	4.033	PROCEDURAL	CLEAR-BUFFER VISUAL-LOCATION
4.883 PROCEDURAL 4.885 DECLARATIVE START-RETRIEVAL 4.885 DECLARATIVE START-RETRIEVAL 4.886 DECLARATIVE START-RETRIEVAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.133 DECLARATIVE START-RETRIEVAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.134 PROCEDURAL 4.135 PROCEDURAL 4.136 PROCEDURAL 4.137 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.139 DECLARATIVE START-RETRIEVAL 4.139 DECLARATIVE RETRIEVAL 4.139 DECLARATIVE RETRIEVAL 4.139 DECLARATIVE RETRIEVAL 4.139 PROCEDURAL 4.139 P	4	4.033	PROCEDURAL	CONFLICT-RESOLUTION
4.083 DECLARATIVE 4.083 PROCEDURAL 4.133 DECLARATIVE STATT-RETREVAL 4.138 PROCEDURAL 4.138 DECLARATIVE STATT-RETREVAL 4.138 DECLARATIVE STATT-RETREVAL 4.138 DECLARATIVE STATT-RETREVAL 4.138 PROCEDURAL 4.138 PROCEDU	4	4.083	PROCEDURAL	PRODUCTION-FIRED RECUPERERVITESSESUCCES
4.983 PROCEDURAL 4.133 PROCEDURAL 4.134 PROCEDURAL 4.135 PROCEDURAL 4.136 PROCEDURAL 4.137 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.139 PROCEDURAL 4.130 PROCEDURAL 4.131 PROCEDURAL 4.132 PROCEDURAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.134 PROCEDURAL 4.135 PROCEDURAL 4.136 PROCEDURAL 4.137 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.138 DECLARATIVE 4.138 DECLARATIVE 4.138 DECLARATIVE 4.138 DECLARATIVE 5.5 PROCEDURAL 5.6 PROCEDURAL 5.7 PROCEDURAL 5.7 PROCEDURAL 5.7 PROCEDURAL 5.8 PROCEDURAL	4	4.083	PROCEDURAL	CLEAR-BUFFER RETRIEVAL
4.083 PROCEDURAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.133 DECLARATIVE START.RETRIEVAL 4.133 DECLARATIVE START.RETRIEVAL 4.133 PROCEDURAL 4.134 PROCEDURAL 4.135 PROCEDURAL 4.136 PROCEDURAL 4.137 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.138 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.139 PROCEDURAL 4.130 PROCEDURAL 4.130 PROCEDURAL 4.130 PROCEDURAL 4.131 PROCEDURAL 4.132 PROCEDURAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.133 PROCEDURAL 4.134 PROCEDURAL 4.233 PROCEDURAL 4.233 PROCEDURAL 4.233 PROCEDURAL 4.233 PROCEDURAL 4.234 PROCEDURAL 4.238 PROCEDURAL 4.238 PROCEDURAL 4.238 PROCEDURAL 4.238 PROCEDURAL 4.238 PROCEDURAL 4.238 PROCEDURAL 4.239 PROCEDURAL 4.330 PROCEDURAL 4.330 PROCEDURAL 4.331 PROCEDURAL 4.331 PROCEDURAL 4.333 PROCEDURAL 4.333 PROCEDURAL 4.339 PROCEDURAL 5.330 PROCEDURAL 6.330	4	4.083	DECLARATIVE	START-RETRIEVAL
4.133 PROCEDURAL 4.133 DECLARATIVE START. RETRIEVAL 4.133 DECLARATIVE START. RETRIEVAL 4.133 DECLARATIVE START. RETRIEVAL 4.134 PROCEDURAL 4.135 PROCEDURAL 4.136 PROCEDURAL 4.137 PROCEDURAL 4.138 PROCEDURAL 4.139 PROCEDURAL 4.130 PROCEDURAL 4.130 PROCEDURAL 6.130 PROCEDURAL 6.131 PROCEDURAL 6.132 PROCEDURAL 6.133 PROCEDURAL 6.134 PROCEDURAL 6.135 PROCEDURAL 6.135 PROCEDURAL 6.136 PROCEDURAL 6.136 PROCEDURAL 6.137 PROCEDURAL 6.138 PROCEDURAL 6.1	4	4.083	DECLARATIVE	RETRIEVAL-FAILURE
4.133 DECLARATIVE START.RETEVAL 4.133 DECLARATIVE START.RETEVAL 4.133 PROCEDURAL CONFLICT.RESOLUTION 4.183 PROCEDURAL PRODUCTION-FIRED REQUESTERSEMANQUEENERGIEKO 4.183 PROCEDURAL CONFLICT.RESOLUTION 4.183 PROCEDURAL CONFLICT.RESOLUTION 4.183 PROCEDURAL CONFLICT.RESOLUTION 4.183 PROCEDURAL CONFLICT.RESOLUTION 4.233 PROCEDURAL CONFLICT.RESOLUTION 4.233 PROCEDURAL CONFLICT.RESOLUTION 4.233 PROCEDURAL CONFLICT.RESOLUTION 4.233 PROCEDURAL CONFLICT.RESOLUTION 4.234 PROCEDURAL CONFLICT.RESOLUTION 4.235 PROCEDURAL CONFLICT.RESOLUTION 4.286 PROCEDURAL CLEAR-BUFFER RETEIEVAL 4.287 PROCEDURAL CLEAR-BUFFER RETEIEVAL 4.288 PROCEDURAL CLEAR-BUFFER RETEIEVAL 4.288 PROCEDURAL CLEAR-BUFFER RETEIEVAL 4.289 PROCEDURAL CLEAR-BUFFER RETEIEVAL 4.280 DECLARATIVE START.RETEVAL 4.281 PROCEDURAL CONFLICT.RESOLUTION 4.283 PROCEDURAL CONFLICT.RESOLUTION 5.40 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.283 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.333 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.334 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.335 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.336 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.337 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.338 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.339 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.339 PROCEDURAL PRODUCTION-FIRED OUBSTITECLASSIQUE 6.349 PROCEDURAL PRODUCTION-FIRED SUBSTITUTE CLASSIQUE 6.349 PROCEDURAL PRODUCTION-FIRED SUBSTITUTE CLASSIQUE 6.349 PROCEDURAL PRODUCTION-FIRED SUBSTITUTE AND PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.349 PROCEDURAL PRODUCTION-FIRED SUBSTITUTE PREDEOURAL TEXTUREPARFAITE 6.349 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.351 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.352 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.353 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.353 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.353 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.354 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.355 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.356 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.357 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.358 PROCEDURAL CLEAR-BUFFER RETEIEVAL 6.358 PROCEDURAL CONFLICT-RESOLUTION 6.359 PROCEDURAL CONFLICT-RESOLUTION 6.350 PROCEDURAL C	4	4.083	PROCEDURAL	CONFLICT-RESOLUTION
4.133 DECLARATIVE STATT.ARTRIEVAL 4.138 PROCEDURAL CONFLICT.RESOLUTION 4.189 PROCEDURAL CLEAR BUFFER RETEIVAL 4.180 PROCEDURAL CLEAR BUFFER RETEIVAL 4.180 PROCEDURAL CLEAR BUFFER RETEIVAL 4.181 PROCEDURAL CLEAR BUFFER RETEIVAL 4.182 PROCEDURAL CLEAR BUFFER RETEIVAL 4.183 PROCEDURAL COMPLICT.RESOLUTION 4.233 PROCEDURAL COMPLICT.RESOLUTION 4.233 PROCEDURAL COMPLICT.RESOLUTION 4.283 PROCEDURAL PRODUCTION-FIRED FOURTERCLASSIQUE 4.283 PROCEDURAL CLEAR BUFFER RETEIVAL 4.283 PROCEDURAL CLEAR BUFFER RETEIVAL 4.283 DECLARATIVE STATT.RETRIEVAL 4.283 DECLARATIVE STATT.RETRIEVAL 4.283 PROCEDURAL COMPLICT.RESOLUTION 4.283 PROCEDURAL PRODUCTION-FIRED COMPRERETEXTURE 4.283 PROCEDURAL COMPLICT.RESOLUTION 4.283 PROCEDURAL PRODUCTION-FIRED FOURTHERCLASSIQUE 4.433 PROCEDURAL COMPLICT.RESOLUTION 4.483 PROCEDURAL PRODUCTION-FIRED FOURTHERCLASSIQUE 4.433 PROCEDURAL COMPLICT.RESOLUTION 4.483 PROCEDURAL COMPLI				
4.133 PROCEDURAL CONFLICT-RESOLUTION 4.184 PROCEDURAL PRODUCTION-FIRED REQUERERVITESSEMANQUEENERGIEKO 4.185 PROCEDURAL CLEAR-BUFFER RETRIEVAL 4.186 PROCEDURAL CONFLICT-RESOLUTION 4.281 PROCEDURAL PRODUCTION-FIRED REQUERERVITESSEMANQUEENERGIEKO 4.283 PROCEDURAL PRODUCTION-FIRED VERTIFICATION 4.284 PROCEDURAL PRODUCTION-FIRED VERTIFICATION 4.285 PROCEDURAL PRODUCTION-FIRED VERTIFICATION 4.286 PROCEDURAL CLEAR-BUFFER RETRIEVAL 4.288 PROCEDURAL PRODUCTION-FIRED VERTIFICATION 4.289 DECLARATIVE START-RETRIEVAL 4.280 DECLARATIVE START-RETRIEVAL 4.280 DECLARATIVE START-RETRIEVAL 4.281 PROCEDURAL CONFLICT-RESOLUTION 4.283 PROCEDURAL PRODUCTION-FIRED VERTIFICATION FOR PROCEDURAL 4.283 PROCEDURAL CONFLICT-RESOLUTION 4.483 PROCEDURAL CONFLICT-RESOLUTION				
4.133 PROCEDURAL 4.183 PROCEDURAL 4.183 PROCEDURAL 4.183 PROCEDURAL 4.233 PROCEDURAL 4.233 PROCEDURAL 4.233 PROCEDURAL 4.233 PROCEDURAL 4.234 PROCEDURAL 4.238 PROCEDURAL 4.238 PROCEDURAL 4.238 PROCEDURAL 4.280 PROCEDURAL 4.281 PROCEDURAL 4.283 DECLARATIVE 5.00 PROCEDURAL 4.283 DECLARATIVE 6.00 PROCEDURAL 6.				
4.183 PROCEDURAL CLEAR-BUFFER RETBIEVAL 4.184 PROCEDURAL CONFLICT-RESOLUTION 4.283 PROCEDURAL CLEAR-BUFFER RETBIEVAL 4.283 DECLARATIVE START-HETREVAL 4.283 DECLARATIVE START-HETREVAL 4.283 DECLARATIVE START-HETREVAL 4.283 PROCEDURAL CONFLICT-RESOLUTION 4.383 PROCEDURAL CONFLICT-RESOLUTION 4.383 PROCEDURAL CONFLICT-RESOLUTION 4.383 PROCEDURAL CONFLICT-RESOLUTION 4.383 PROCEDURAL CONFLICT-RESOLUTION 4.483 PROCEDURAL CLEAR-BUFFER RETRIEVAL 4.483 DECLARATIVE START-RETEVAL 4.483 DECLARATIVE RETBIEVED-CHINK TEXTUREPARFAITE 4.483 DECLARATIVE RETBIEVED-CHINK TEXTUREPARFAITE 5.784 PROCEDURAL CONFLICT-RESOLUTION 5.785 PROCEDURAL CONFLICT-RESO				
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# 4. Apprentissage

#### 4.1 Casser et séparer les œufs

Afin de permettre à notre modèle de s'améliorer et d'apprendre de ses erreurs, nous avons mis en place deux méthodes d'apprentissage. La première est basée sur les habitudes et le principe en ACT-R de *reward*. En effet, pour que le comportement de notre modèle soit le plus humain possible, nous avons décidé qu'il serait possible qu'il fasse tomber des coquilles ou du jaune d'œuf dans la préparation au moment où il les casse et les sépare. Cette possibilité se traduit par des procédures possédant les mêmes préconditions, l'une ajoutant une coquille ou du jaune et l'autre non. Lorsqu'une de ces procédures est utilisée, un *reward* lui est appliqué dans le but de favoriser les procédures ne rajoutant pas de coquille ou de jaune dans la solution. Les figures 1 et 2 illustrent le pourcentage moyen de coquilles ou de jaunes mis dans la préparation pour tous les modèles à chaque itération. Par exemple, chaque expérience se faisant avec quatre œufs, une moyenne de 25% pour une itération sur la figure 1 indiquerait que chaque modèle a mis en moyenne une coquille sur les quatre œufs cassés lors de cette itération.

Nous avons aussi cherché à ce que cet apprentissage soit optimal après 5 itérations (soit 20 œufs cassés et séparés), tout en gardant toujours une probabilité non nulle d'ajouter des coquilles et du jaune car comme les humains, notre modèle n'est pas infaillible. Nous considérons en effet qu'après avoir cassé et séparé une vingtaine d'œufs, une personne ordinaire a appris à ne presque plus faire tomber de coquille ou de jaune. Nous avons cependant pris la décision de garder une probabilité non nulle de mal casser ou de mal séparer le jaune du blanc car nous pensons aussi qu'il arrive de temps en temps d'être maladroit.

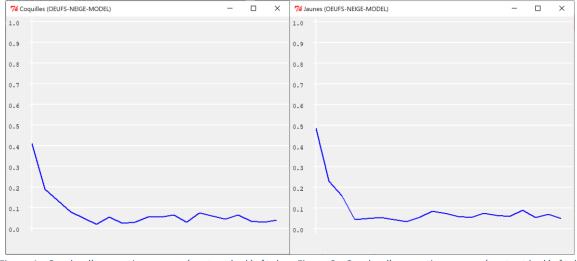


Figure 1 - Courbe d'apprentissage représentant le dépôt de coquille sur 20 itérations (80 cassage d'œufs) Figure 2 - Courbe d'apprentissage représentant le dépôt de jaune sur 20 itérations (80 cassages d'œufs)

#### 4.2 Monter les blancs en neige

Concernant la montée des blancs en neige, nous avons choisi de nous inspirer du Lab 4 en utilisant un chunk d'apprentissage. Le chunk *experienceFouettage* permet ainsi au modèle de se souvenir de ses tentatives passées afin de progresser vers la réussite du but principal. Cette progression est réalisée dans ACT-R grâce au rappel d'une précédente expérience et à la modification de la vitesse utilisée précédemment. La génération de la vitesse par défaut, c'est-à-dire la vitesse utilisée par le modèle au cours de sa première itération, utilise deux paramètres ayant pour but, d'une part, de permettre à deux exécutions indépendantes du modèle d'être différentes, et d'autre part, de procurer une certaine flexibilité d'apprentissage au modèle : le premier paramètre est la vitesse minimale permettant en pratique de définir une vitesse par défaut minimale mais aussi de définir le point de départ pour l'apprentissage du modèle alors que le deuxième paramètre est la marge aléatoire qui représente la taille de l'intervalle dans lequel nous tirons un nombre aléatoire que nous ajoutons à la vitesse minimale. Cela permet ainsi d'avoir une vitesse par défaut propre à chaque modèle.

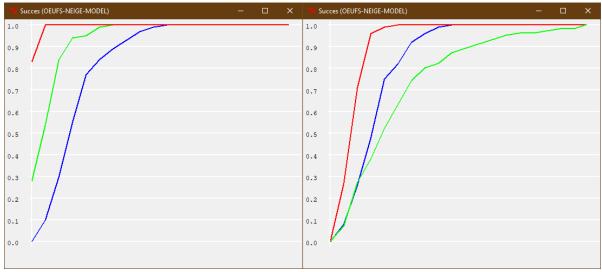


Figure 3 - Courbe d'apprentissage représentant la montée des blancs en neige au fil des itérations en modifiant la vitesse minimale

Figure 4 - Courbe d'apprentissage représentant la montée des blancs en neige au fil des itérations en modifiant la marge aléatoire

Les figures 3 et 4 ci-dessus illustrent donc les différentes courbes d'apprentissage en fonction de la valeur des paramètres fixée. Sur la figure 3, la courbe de référence, en bleu, avec une vitesse minimale de 15, nous indique qu'aucun modèle n'a réussi à monter les blancs en neige au cours de la première itération. En revanche, la courbe verte correspondant à une vitesse de 10 et la rouge à une vitesse de 5, montrent que moins de 10% des modèles n'ont pas réussi à obtenir de blancs en neige à la première itération. D'un autre côté, la modification de la marge aléatoire sur la figure 4 influe sur la progression de l'apprentissage des modèles. La courbe bleue représente, là encore, la courbe de référence avec les mêmes paramètres que la courbe bleue du précédent graphique. Nous voyons ainsi qu'en réduisant la marge aléatoire (courbe rouge), le modèle semble devenir plus performant à la tâche. A contrario, la courbe verte nous montre qu'en augmentant cette marge aléatoire, le modèle a plus de difficulté à arriver aux 100% de réussite.

### 5. Conclusion

La réalisation de ce modèle montant des blancs d'œufs en neige n'a pas été chose aisée mais nous avons réussi à développer la totalité des objectifs que nous nous étions fixés au départ : notre modèle est en mesure de casser des œufs, séparer le blanc du jaune et fouetter les blancs jusqu'à l'obtention d'une texture en neige. Nous avons jugé intéressant d'ajouter un second type d'apprentissage, par l'habitude, pour les étapes de cassage et de séparation des œufs bien qu'il ne soit pas initialement prévu. En effet, il nous a permis de réutiliser les compétences acquises du Lab 5, ce qui complète parfaitement celles du Lab 4 que nous utilisions pour l'apprentissage du fouettage. Les résultats obtenus simulent un apprentissage plutôt cohérent avec la réalité : ils sont proches de ceux qu'un être humain pourrait obtenir.

Notre modèle n'est, toutefois, pas parfait. En effet, le nombre d'œufs pour chaque itération est fixé à 4, ce qui n'est pas très représentatif de la réalité. De plus, les paramètres fixés pour représenter la vitesse de fouettage ainsi que la couleur et le volume de la texture restent assez abstraits : ils ne sont pas basés sur des expériences que nous aurions faites en situation réelle. Le modèle mathématique choisi pour représenter le geste de fouettage manque également de réalisme. Il serait donc intéressant de mener des expériences pour mesurer ces données et modéliser au mieux la situation.

Bien que nous soyons satisfaits de notre modèle, nous avons réfléchi à d'éventuelles améliorations pour une évolution future. Au-delà de corriger les défauts de modélisation cités plus haut, nous pourrions également ajouter la possibilité d'augmenter temporairement la vitesse de fouettage, permettant au modèle de réaliser un « rush » dans un dernier espoir d'avoir la texture si celle-ci ne monte pas. Il serait également intéressant de prendre en compte un éventuel échec lors du nettoyage des jaunes, ce qui aurait un impact sur la montée des blancs. Enfin, il serait plus réaliste d'adapter l'énergie du modèle selon sa forme physique car il se peut qu'il ne puisse pas réussir si un jour il est trop fatigué.

Finalement, notre projet est adaptable à une multitude de situations en cuisine. Il est possible de le décliner pour toutes les recettes nécessitant de casser des œufs, séparer le jaune et le blanc et fouetter la préparation comme, par exemple, blanchir des jaunes, réaliser une meringue et bien d'autres.